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THE GERMPLASM AS A STEREOCHEMIC SYSTEM[1]

THE discovery in 1883 by Dr. S. Weir Mitchell and myself that the toxic principles of the venoms of serpents are albuminous marked an era in the chemistry, physiology and pathology of proteins, and among other things laid the foundation of our knowledge of bacterial and other toxalbumins. Since that time our information of the properties of albuminous substances, then extremely meager and somewhat chaotic, has greatly advanced, and many investigations have been made to determine the precise nature of these poisons, with the effect of more or less modifying the statements we then set forth. The astonishing fact that these terribly lethal substances were found by the tests of the day to be proteins, and that apart from their toxic properties they were indistinguishable from corresponding bodies that are ingested as food or derived therefrom by the processes of digestion, or found as normal constituents of the living tissues generally, naturally led me to much speculation and ultimately to the pursuit of the very elaborate series of researches that I have been carrying on during the past decade under the auspices of the Carnegie Institution of Washington, reports of two of which have appeared as Publications Nos. 116 and 173.

It would be futile for me to attempt within the necessarily restricted time that can reasonably be allotted to the reading of a communication to present in a satisfactory form even the briefest summary of the very voluminous results and conclusions that are embodied in these works, or even an outline of

[1] Read by title at the meeting of the American Philosophical Society, April 25, 1914, and in full before the Society of Normal and Pathological Physiology of the University of Pennsylvania, April 28, 1914.

their bearings upon a vast number of problems of normal and abnormal biology, so that perforce my remarks shall be limited to a fragment—a fragment which bears upon one of the most baffling yet all-absorbing problems of life, why "like begets like."

A. The Specificity of Stereoisomerides in Relation to Genera, Species, etc.

These researches have as their essential basis the conception that *in different organisms corresponding complex organic substances that constitute the supreme structural components of protoplasm and the major synthetic products of protoplasmic activity are not in any case absolutely identical in chemical constitution, and that each such substance may exist in countless modifications, each modification being characteristic of the form of protoplasm, the organ, the individual, the sex, the species and the genus.* This conception was supported not only by the extraordinary differences noted between the albuminous substances of venom and those of other parts of the serpent, but also by the results of the investigations of Hanriot, who described marked differences in the properties of the lipases of the pancreatic juice and the blood; of Hoppe-Seyler and others who stated that the pepsins of cold- and warm-blooded animals are not identical; of Wróblewsky and others who recorded differences in the pepsins of mammals; of Kossell and his students who found that the protamins obtained from the spermatozoa of different species of fish are not identical; and of various observers who have noted that the erythrocytes of one species when injected into the blood of another are in the nature of foreign bodies and rapidly destroyed. During subsequent years, and especially very recently, data have been rapidly accumulating along many and diverse lines of investigation which collectively indicate that every individual is a chemical entity that differs in characteristic particulars from every other. To any one familiar with the advances of biochemistry and with the trend of scientific progress towards the explanation of vital phenomena on a physico-chemical basis, it will be obvious that if the conception of the non-uniform constitution of corresponding proteins and other corresponding complex organic substances in different organisms and parts of organisms were found to be justified by the results of laboratory investigation a bewildering field of speculation, reasoning and investigation would be laid open—a field so extensive as to include every domain of biological science, and seemingly to render possible, and even probable, a logical explanation of the mechanisms underlying the differentiation of individuals, sex, varieties, species and genera; of the causes of fluctuations and mutations; of the phenomena of Mendelism and heredity in general; of the processes of fecundation and sex-determination; of the tolerance of certain organisms to organic poisons that may be extremely virulent to other forms of life; of tumor formation, reversions, malformations and monsters; of anaphylaxis, certain toxemias, immunities, etc.; and of a vast number of other phenomena of normal and abnormal life which as yet are partially or wholly clothed in mystery.

Some years previous to the discovery of the nature of the lethal constituents of venoms, Pasteur found that there exist three kinds of tartaric acid which, because of different effects on the ray of polarized light, are distinguished as the dextro-, lævo- and racemic-tartaric acids, the dextro form rotating the ray to the right, the lævo form to the left, and the racemic form not at all. When these acids were subjected in separate solutions to the actions of *Penicillium glaucum* fermentation proceeded in the dextro form, but not in the lævo form, while in the solution of the racemic acid, which is a mixture of the dextro and lævo acids, the dextro form disappeared, leaving the lævo moiety unaffected. All three acids have the same chemical composition and chemical properties, but differ strikingly in their effects on polarized light and in nutritive properties. Identical or corresponding peculiarities have since been recorded in relation to a large number of substances. Thus, of the twelve known forms of hexoses, or glucoses, only the dextro forms are fermentable,

that is, capable of being used by certain low organisms as food, but not all are thus available, and, moreover, those which are show marked differences in the degree of fermentability. In the case of other substances *Penicillium* may consume the lævo form, but not the dextro form. Other organisms show similar selectivities, using either dextro or lævo form, or both, but in the latter case in unequal degree. Even more striking instances have been recorded in the actions of poisons, as, for instance, dextro-nicotine is only half as toxic as the lævo form; dextro-adrenalin has only one twelfth the power of the lævo form; racemic-cocaine has a quicker and more intense but less lasting action than the lævo form; the asparagines, hyoscines, hyoscyamines and other substances have been found to exhibit marked differences in accordance with variations in their optical properties. With other bodies belonging to this category it may be found that one form is sweet while another is tasteless; another may be odorous, but its enantiomorphous form without odor.

To the foregoing there may be added examples of other substances that exist in several forms, but which physico-chemically belong to a different class. Thus, nitroglycerine may exist in forms that are so different that under given conditions of temperature and percussion one is explosive and the other non-explosive. Differences in substances which are found in allotropic forms may be as marked as in any of the preceding illustrations, as, for instance, in the case of phosphorus, which is familiar as the yellow, white, black and red varieties, all of which with the exception of red phosphorus are exceedingly poisonous, while the latter is inert. The ortho, meta and para forms of a given substance may exhibit more or less marked physiological and toxicological variations, and so on.

The explanation of the remarkable differences shown by these substances, which differences are paralleled by those manifested by the lethal and innocuous proteins of the serpent, the pepsins, the protamins and the red blood corpuscles is to be found in the results of two independent but intimately related lines of physico-chemical research: (1) The investigations of Van't Hoff and LeBel and subsequent observers which have laid the foundation of a new, and to the biologist and physician an extraordinarily important, development of chemistry known as stereochemistry—a department that treats of the arrangements of the atoms, groups and masses of molecules, or in other words of intramolecular arrangement or configuration of molecular components in the three dimensions of space. (2) The investigations of Willard Gibbs and others which have given us the "phase rule," which defines the phases or forms in which a given substance or combination of substances may exist owing to differences in intramolecular and extramolecular arrangements and concentration of their components in relation to temperature and pressure.

According to stereochemistry a given substance may exist in multiple forms dependent upon differences in the configuration of the molecule, all of which forms have in common the fundamental chemical characteristics of a given prototype, yet each may have certain properties which positively distinguish it from the others. Theoretically, such substances as serum albumin, serum globulin, hemoglobin, starch, glycogen and chlorophyl may be produced by nature in countless modified forms, owing to differences in intramolecular arrangements. Miescher has estimated that the serum globulin molecule may exist in a thousand million forms. Substances that exist in such multiple forms of a prototype are distinguished as stereoisomers. The remarkable fact has been noted by Fischer and others that stereoisomers may exhibit as great or even greater differences in their properties than those manifested by even closely related isomers, which latter in comparison with stereoisomers are distantly if at all chemically related. As already instanced, so slight a change in molecular configuration as gives rise to dextro and lævo forms may be sufficient to cause definite and characteristic and even profound differences in physical, nutritive and physiological properties.

In accordance with the "phase rule" a sub-

stance or a combination of substances may exist in the form of heterogeneous or homogeneous systems, a heterogeneous system consisting of a number of homogeneous systems, each of which latter is a manifestation of an individual phase and distinguishable from the others by physical, mechanical, chemical or physiological properties. The number of phases of a heterogeneous system increases with the number of component systems, and the number of the latter is in direct relationship to the number of independent variable constituents. Therefore, by means of variations of either or both intramolecular or extramolecular arrangement the number of forms of a substance or combination of substances may range from few to infinite.

Our means of differentiating stereoisomers are, on the whole, limited, and for the most part crude, and while it has been found that differences so marked as those referred to may be detected by the ordinary procedures, it seems obvious that the inherent limitations of such methods render them inadequate where a large number of stereoisomerides or related bodies which may exhibit only obscure modifications are to be definitely differentiated, so that other and more sensitive methods must be sought, or at least special methods that are adapted to exceptional conditions. The results of much preliminary investigation in this direction led in one research to the adoption of the crystallographic method, especially the use of the polarizing microscope, which in its very modern developments of analysis has demonstrated that substances which have different molecular structures exhibit corresponding differences in crystalline form and polariscopic properties; and, moreover, that the "optical reactions" may be found to be as distinctive and as exact analytically as the reactions obtained by the conventional methods of the chemist. Furthermore, the necessities of the hypothesis demanded the selection of a substance for study of a character which upon theoretical grounds might be expected to exist in nature widely distributed and readily procurable, and, as a consequence, hemoglobin was selected.

In the investigation of the hemoglobins I had as a coworker Professor Amos Peaslee Brown. Hemoglobins were examined that were obtained from over 100 animals, representing a large variety of species, genera and families. From the data recorded certain facts are especially conspicuous, among which may be mentioned the following:

1. The constant recurrence of certain angles, plane and dihedral, in the hemoglobins of various species, even when the species are widely separated and the crystals belong to various crystal systems. This feature indicates a common structure of the hemoglobin molecules, whatever their source.

2. The constant recurrence of certain types of twinning in the hemoglobins, and the prevalence of mimosie. This has the same significance as the foregoing.

3. The constancy of generic characters in the crystals. The crystals of the various species of any genus belong to a crystallographic group. When their characters are tabulated they at once recall crystallographic groups of inorganic compounds. The crystals of the genus *Felis* constitute an isomorphous group which is as strictly isomorphous as the groups of rhombohedral and orthorhombic carbonates among minerals, or the more complex molecules of the members of the group of monosymmetric double sulphates.

4. The crystallographic specificity in relation to species. The crystals of each species of a genus, when they are favorably developed for examination in the polarizing microscope, can usually be distinguished from each other by definite angles and other properties, while preserving the isomorphous character belonging to the genus. Where, on account of difficulty of measurement, the differences can not be given a quantitative value variations in habit and mode of growth of the crystals often show specific differences.

5. The occurrence of several types of oxyhemoglobin in members of certain genera. In some species the oxyhemoglobin is dimorphous and in others trimorphous. Where several types of crystals occur in this way in the species of a genus the crystals of each type

may be arranged in an isomorphous series. In other words, certain genera as regards the hemoglobins are isodimorphous and others isotrimorphous.

6. When orders, families, genera or species are well separated the hemoglobins are correspondingly markedly differentiated. For instance, so different are the hemoglobins of *Aves, Marsupialia, Ungulata* and *Rodentia* that there would be no more likelihood of confounding the hemoglobins than there would be of mistaking the animals themselves. Even where there is much less zoological separation, as in the case of the genera of a given family, but where there is well-marked zoological distinction, the hemoglobins are so different as to permit readily of positive diagnosis. When, however, the relationships are close the hemoglobins are correspondingly close, so that in instances of an alliance such as in *Canis, Vulpes* and *Urocyon,* which genera years ago were included in one genus (and doubtless correctly) the hemoglobins are very much alike, and in these cases they may exhibit closer resemblances than may be found in general in specimens obtained from well-separated species of a genus.

So distinctive zoologically are these modified forms of hemoglobins that we had no difficulty in recognizing that the common white rat is the albino of *Mus norvegicus* (*Mus norvegicus albus* Hatai) and not of *Mus rattus,* as almost universally stated, and that Ursidæ are related to Phocidæ (as suggested by Mivart 30 years ago), but not to Canidæ, as stated in modern works on zoology. Moreover, we were quick to detect errors in labeling, as, for instance, when a specimen marked as coming from a species of *Papio* was found to belong to one of the Felidæ. Generic forms of hemoglobin when obtained from well-separated genera are, in fact, so different in their molecular structures that when any two are together in solution they do not fuse to form a single kind of hemoglobin or a homogeneous solution, but continue as discrete disunited particles, so that when crystallization occurs each crystallizes independently of the other and without modification other than that which is dependent upon such incidental conditions as are to be taken into account ordinarily during crystallization. Thus, the hemoglobin of the dog crystallizes in rhombic prisms which have a diamond-shaped cross-section; that of the guinea-pig in tetrahedra; that of the squirrel in hexagonal plates; and that of the rat in elongated six-sided plates. When any two of these hemoglobins are together in solution and crystallization occurs, each appears in its own form. Such phenomena indicate that the structures of the hemoglobin molecules are quite different; in fact, more differentiated than the molecules of members of an isomorphous group of simple carbonates, such as the carbonates of calcium and magnesium which when in separate solutions crystallize in rhombohedrons whose corresponding angles differ 2° 15′, but which when in molecular union, as in the mineral dolomite, crystallize as a single substance which has an intermediate angle.

Upon the basis of our data it is not going too far to assume that it has been satisfactorily demonstrated theoretically, inferentially and experimentally that at least this one substance (hemoglobin) may exist in an inconceivable number of stereoisomeric forms,[2] each form being peculiar to at least genus and species and so decidedly differentiated as to render the "hemoglobin crystal test" more sensitive in the recognition of animals and animal relationships than the "zooprecipitin test."

Subsequent to the research referred to investigations have been pursued in the study of hemoglobins from various additional sources, especially from representatives of *Primates,* with the result in the latter case of finding indubitable evidence of an ancestral alliance of man and the man-like apes.

More or less elaborate studies by crystallographic and other methods have also been made with other albuminous substances and with starches, glycogens, phytocholesterins, chlo-

[2] Even if we assume that the different forms are not, strictly speaking, stereoisomers it must be admitted that hemoglobin exists in forms that are specifically modified in relation to genera and species.

rophyls and other complex synthetic products of animal and plant life, especially with starches, of which over 300 specimens were examined that were obtained from different plant sources, including representatives of a considerable number of families, genera, species, varieties and hybrids. In all of these investigations the results are not only in full accord with those of the hemoglobin researches but also in some instances of broader significance because by better methods of differentiation in some cases it was found possible to recognize not only peculiarities as regards genus or species, but also varieties and hybrids, and even to trace in hybrids with marked definiteness the transmission of parental characteristics.

Summing up the results of these independent but interwoven researches, we find that the modified forms of each of these substances lend themselves to a very definite system of classification, and to one that is in general accord with that of the botanist and zoologist, that is, each genus is characterized by a distinctive type of hemoglobin, albumin, starch, etc., as the case may be, which may be designated the generic-type; every species of the genus will have a modification of this type, which is a species-type, or generic primary sub-type; and every variety of a species will have a modification of the species-type, that is a variety-type, or generic secondary sub-type, or species sub-type. In fact, it seems clear that with revisions of present classifications that are certain to come there will be found definite family types; and, moreover, that with improved methods of differentiation there will be discovered positively distinctive sex- and individual-types. This last statement already has support in the results of collateral lines of research which bear upon the specificities of enzymes, anaphylaxis, precipitin reactions, immune sera, etc.

From the foregoing data it seems obvious that *the complex organic substances which may be assumed to constitute the essential fundamental constituents of protoplasm and the immediate complex synthetic products of protoplasmic activity may exist in exceedingly numerous or even countless stereoisomeric forms, each form being peculiarly and specifically modified in relation to genus, species, variety, race, sex, individual or even part of an individual.*

B. Protoplasm a Complex Stereoisomeric System

The next logical step in our investigation is manifestly the study of the bearings of these stereoisomers, as such and in their variable combinations and associations, upon the structure, processes and products of protoplasm. Protoplasm according to the modern developments of biochemistry is to be regarded as being in the nature of an extremely complex, labile aggregate of proteins, fats, carbohydrates and other substances that are peculiarly associated to constitute a physico-chemical mechanism. The possible number of "phases" in which such a system can exist varies with the forms of the stereoisomerides and in general with the number and independent variability of the components. In such a mechanism we conceive that the number of variables is inconceivably great. From analogy we believe that such mechanisms are so extremely sensitive that the properties and processes may be modified by even so slight a change as the substitution of one form of stereoisomeride for another of the same prototype. Were it practicable to examine all of the most complex of the organic structural components of protoplasm, it doubtless would be found that every one exists in a form that is peculiar to the individual and his position in classification. Moreover, we must conceive that the components of protoplasm are as specific in relation to the form of protoplasm as are the peculiar forms of stereoisomers, so that different forms of protoplasm are characterized physico-chemically (1) by the peculiarities of the stereoisomerides, and (2) by the peculiarities of the kinds, combinations, associations and arrangements of the components in the three dimensions of space.

In accordance with the foregoing the human organism may be regarded as being a highly organized composite of heterogeneous physico-

chemical systems that are composed of a vast number of parts, each such part representing a particular "phase" of the system and being physically, mechanically, chemically and functionally an individual interacting unit of the aggregate. Hence, it follows that the sum or totality of these peculiarly modified stereoisomers *per se*, and of their arrangements with the associated components, constitutes a "stereochemic system" that is peculiar to the cell; that the sum of the cell-systems is peculiar to the tissue; that the sum of the tissue-systems is peculiar to the organ; and that the sum of the organ-systems is peculiar to the individual.

While the living organism had been for years recognized as being in the nature of an exceedingly complex physico-chemical aggregate of interacting independent and interdependent parts that constitute a single working unit, it has been in only recent years that the mechanisms that bring about cooperative activities of the various parts has been made clear. The governing influences of the nervous system were found inadequate even in the highest organisms, not to speak of forms of life in which such actions occur, but in which there is apparently a total absence of nervous matter. As an associate of the nervous system, and doubtless far antedating it in organic evolution, is a correlative mechanism of a chemical character that is of the greatest importance, and doubtless equally so throughout the whole range of living organisms from the lowest to the highest. Every living cell, whether it be in the form of a unicellular organism or a component of a multicellular organism, is undoubtedly in the nature of a heterogeneous stereochemic system, each of the component parts of the system forming substances which may affect directly or indirectly the activities of the processes of the other parts; likewise every cell of a multicellular organism is not only in itself a heterogeneous system, but a part of a number of associated heterogeneous systems and which by virtue of certain of its products, with or without the agency of the blood-vascular or lymph-vascular systems, may exercise influences upon other structures, which structures may have or seemingly not have either structural or physiological relationship. Thus we find that a secretin formed in the pyloric glands of the gastric mucosa may excite the glands of the cardia; that growth is determined by some product or products of the pituitary body that are carried to the various structures; that the liver, pancreas and intestinal glands are excited to secretory activity by a peculiar substance formed in the duodenal and jejunal mucosæ; that carbohydrate metabolism in the liver and muscle is influenced to a profound degree by hormones that are formed in the pancreas; that lactation is determined essentially by substances derived from the corpus luteum, placenta and involuting womb; that the periods of ovulation and menstruation are inhibited by secretins of the corpus luteum; that vitally important states of activity of the generative organs are directly associated with functions of the adrenal glands; and that normal development, especially of secondary sexual characters, is intimately related to the ovaries and testicles. To these extraordinary correlations might be added many others. Some of the bodily structures are in this way so definitely associated in their activities as to constitute cooperating or interacting systems, so that the tissue products are complementary, supplementary, synergistic or antagonistic in their influences upon given structures. Such correlations must be, for perfectly obvious reasons, one of the most primitive forms of interprotoplasmic correlation, and we are justified, upon the basis of our present knowledge, in the conclusion that each active part of a cell, each cell, each tissue and each organ contributes products which may affect the activities of functionally related or unrelated parts. Hence would follow the dictum that *not only is every part of a cell, every cell, every tissue and every organ an individualized stereochemic unit, but also that its operations, and hence the nature of its products, must be subject directly or indirectly to the influence of every other active part of the organism, however different the structures and functions may be.*

C. The Germplasm a Stereochemic System, that is, a Physico-chemical System that is Particularized by the Characters of its Stereoisomers and the Arrangements of its Components in the Three Dimensions of Space

If during the progress of development there arise the multiple forms of differentiated protoplasm that are represented in the nerve cells, muscles, glands, etc., which exhibit such diversity of form, functions, composition and products, each part being correlated to other parts by the agency of tissue products, it is logical to assume that in the development of the ovaries and testicles these organs have been so specialized as to endow them with the attribute of producing a form of protoplasm that embodies in a germinal state the fundamental peculiar stereoisomerides and the peculiar arrangements or phases of the associated proteins, fats, carbohydrates and other substances which inherently characterize the organism; and, moreover, that owing to the influences of the products of activity of the various tissues upon these organs, such changes in the organism as give rise to acquired characters may through the actions of modified or new tissue products or foreign substances affect the operations of these organs and thus alter the germplasm and consequently become manifested in some form in the offspring. The ovule in its incipiency is conceived to be comparable to a complex unequilibrated solution in which changes go on until the attainment of full development, at which time it is equilibrated and remains inactive because of the absence of some disturbing influence, but in which energy-reactions may be initiated physically, mechanically or chemically, and proceed according to definite physico-chemical laws in definite directions to a definite end. As, for instance, when a solution of boiled starch and diastase is at a temperature below the minimal of activity and the temperature is raised, causing immediate developmental activation; or when the equilibrated molecules of nitroglycerine are exploded by percussion; or when an equilibrated maltose-dextrose-maltase solution is rendered active by dilution with water.

The *nature of the germplasm* or transmissive material that serves as the bridge of continuity between parents and offspring has been the subject of speculation from time immemorial. Such hypotheses and theories as have been advanced have had reference almost wholly to its physical constitution or ultimate morphological structure. Most of them are micromeric, that is, they hold that the germplasm is made up of infinite number of discrete ultramicroscopic particles which are endowed with both determinate structural and vital attributes. A considerable degree of ingenuity has been displayed in their formulation. Thus, we have the "organic molecules" of Buffon, the "microzymes" of Bèchamp, the "life units" of Spencer, the "plastidules" of Maggi, the "bioplasts" of Altmann, the "stirps" of Galton, the "gemmules" of Darwin, the "biophors" of Weismann, the "pangens" of DeVries, etc., each author attributing to the units certain inherent peculiarities. To the foregoing might be added particularly the conceptions that belong to the chemical category, such as the "chemism" of LeDantec and the "physico-chemical" theory of Delage. Some of these conceptions are so fanciful in the light of modern science as to be unworthy of more than passing consideration, while none of them has led anywhere beyond the field of speculation and reasoning. Even the very recent and extremely interesting and important additions to our knowledge of the histological phenomena of the developing ovum, especially of the chromosomes, have not taken us appreciably nearer the ultimate constitution or mechanism of the germplasm, or even to the nature of the reactions which occur immediately antecedent to and cause the formation of the chromosomes.

A theory to be *ideal* must not only have as its basis well-defined principles that are consistent with facts, but also be capable of substantiation by laboratory investigation. Given as the basis of scientific study a germplasm that has inherently the power of development; that is in the form of a stereochemic system that is peculiar to the organism; that is highly impressionable to stimuli; and that has the

marked plasticity that is inherent to organic colloidal matter, we have all the postulates that are needed as a foundation upon which, according to the laws of physical chemistry, can be built a logical explanation of the essential fundamental elements of the mechanism of heredity.

The *inherent potentiality* that determines the development of the egg along a line of definite sequential processes must be recognized as being common to both animate and inanimate matter and subject to the same laws, so that the phenomena of living and dead matter are inseparably linked and reciprocally explanatory. The typical condition of matter of definite composition is crystalline, and the crystalline form is the result of development that becomes manifested in a separation and orderly and progressive arrangements of components in the three dimensions of space. Having a homogeneous solution of various selected crystalline substances of appropriate chemical composition and constitution, and given conditions attendant to crystallization, the successive stages of crystalline development will proceed along fixed and definitely recognized lines, and the interactions and interaction-relationships between the various substances constituting the physico-chemical mechanism become obvious to a greater or less extent in the peculiarities of form, composition and other properties of the crystals. Having in the germplasm an analogous physico-chemical system, but one which is markedly different especially because of its organic and colloidal character and infinitely greater molecular complexity and sensitivity, the phenomena of development likewise proceed in conformity with the same laws along definite lines, but they are for perfectly manifest reasons more complex and varied, more difficult of analysis, and necessarily in many very important respects quite different. Each step in this orderly development leads not merely to changes of the physico-chemical mechanism by the modification, rearrangement, or splitting off of component parts, but also to alterations which automatically determine the characters of the next succeeding step, and so on to the establishment of physico-chemical equilibrium and the consequent termination of the reactions.

In living matter the chemical processes are dependent to a preeminent degree upon enzymes that are formed by the different kinds of protoplasm to serve as implements to carry out operations that are essential to their existence, and such enzymes are modifiable in quantity and quality in accordance with changes in internal and external conditions. The nature of both reactions and products of enzymic action depends upon the constitution and composition of the physico-chemical mechanism of which the enzyme is an integral part. Whether or not at each step of serial reactions a portion of preexisting enzyme is merely modified or a new enzyme is formed which constitutes an essential part of the particular phase of the reactions is not known, but that one or the other occurs is apparently without question. It has long been established that some of the lower organisms, such as the yeast plant, have the property of modifying the characters of the enzymes produced in relation to varying conditions; recent studies of the animal organism show that the same phenomenon occurs in both tissues and blood; and our knowledge of the processes concerned in the catabolism and anabolism of complex substances, such as starch, is fully in support of such a conception. In other words, as each step of development is reached the alterations which occur in the physico-chemical mechanism absolutely automatically predetermine the characters of the changes of the next succeeding step, and so on to the end. Hence it follows that the peculiarities of any given physico-chemical mechanism predetermine the characters of the phenomena which ensue under given conditions.

An illustration of the probable *modus operandi* of such a mechanism is found in the phenomena of the synthesis and analysis of starch: During the production of starch through the agency of the chloroplast or leucoplast we conceive that there are instituted a predetermined, orderly, independent and interdependent series of reactions, the first

of which is manifested in an interaction between water and carbon dioxide through the agency of an enzyme in the form of an oxidase to form formaldehyde. During this process there is formed another enzyme, which tentatively may be designated an aldehydase, that reacts with formaldehyde and by polymerization and condensation of six molecules gives rise to a simple sugar, such as dextrose. At the same time another enzyme appears in the form of maltase, which, reacting with the dextrose causes the formation of maltose, during which reaction another enzyme, a dextrinase, is produced which reacts with the maltose to yield dextrin. Going on with this reaction, another enzyme which may be designated an amylase appears, which, reacting with the dextrin, forms soluble starch. During this stage there arises another enzyme, a coagulase, which converts the starch from the soluble to the insoluble form or ordinary starch. At this stage the series of reactions have reached their end because a state of physico-chemical equilibrium has become established, the ultimate purpose of the processes being attained; that is a form of pabulum of extremely high nutritive value and of extremely low molecular pressure, even in soluble form, so that it may entirely and rapidly disappear without disturbance of physico-chemical equilibrium in the starch-bearing cells. The mechanism concerned in starch-formation is without doubt paralleled in the synthesis of proteins, fats and other complex organic substances, and it is but a step from the individual serial processes concerned in the formation of each of these substances to associated processes whereby there are formed and combined the various substances that constitute the organic structural components of protoplasm. Moreover, such serial processes are reversible at any stage, and so simple a modification as a change in the per cent. of water may, as in the maltose-dextrose-glucase reaction, cause a synthetic change.

In vitro in both synthetic and analytic processes like those which constitute serial steps in the building up and breaking down of starch, protein, fat and other complex organic substances there does not occur in any reaction, as far as known, either a transformation or a production of enzyme such as occurs *in vivo*, hence, when a single enzyme is present it carries out but one step of the reactions, but when, as in the case of diastases as ordinarily prepared, the enzyme is not a single substance or unit body but a composite of a number of enzymes or modifications of a given basic enzyme, serial steps may occur as *in vivo*. Thus, if only a single enzyme be present formaldehyde may be converted into a monosaccharose, or a monosaccharose into a disaccharose, or a disaccharose into a polysaccharose such as dextrin, or dextrin into a higher form of polysaccharose such as soluble starch, according to the enzyme or modified enzyme and initial substance present; or the reverse of any one of these processes may occur if proper conditions are present, but never do any two successive progressive or regressive steps occur unless through the agency of two different or modified forms of enzymes which are present.

It will thus be apparent that the first step of synthesis is determined by the character of the initial physico-chemical mechanism and that all subsequent reactions under given conditions are definitely predetermined; in other words, the entire train of reactions depends inherently upon the nature of the initial physico-chemical mechanism of which the enzyme that starts the serial changes is an integral part.

Having a specific stereochemic system, such a system in accordance with the laws of physical-chemistry can exist in either a latent or active state, and that when in an active state the reaction or reactions are always in the direction of the establishment of equilibrium of solution, every reaction or series of reactions being as definitely predetermined as is every reaction familiar to the inorganic chemist. The germplasm in the form in which it is secreted may be regarded as being in the nature of an exceedingly complex stereochemic system which is from its incipiency, or very soon is in a state of physico-chemical unequilibrium, and in which, as a consequence,

reactions are set up which are manifested especially in histological developments that ultimately characterize the fully developed ovule, at which time a state of physico-chemical equilibrium is established, as is evident by the arrested developmental activities. This state of physico-chemical equilibrium of the matured ovule may be instantly changed to one leading to serial definitely predetermined reactions by means of an activating substance or condition, such as certain ions or inorganic salts, a spermatozoon, or a needle prick, by initiating the first step of the reactions, the nature of the succeeding reactions being predetermined primarily by the inherent nature of the physico-chemical system and secondarily by the factor that activates it. In other words, from this initial stereochemic system there arises a complex heterogeneous system that ultimately is morphologically expressed in the histology of the matured ovule and from which are formed a composite of correlated, independent, interdependent and differentiated masses which represent different phases of the components of the initial system which have been modified not only physico-chemically as expressed by changes in physical, mechanical and chemical properties, but also in developmental energies; and from this composite are developed successively other systems.

Owing to the *great impressionability and plasticity* of such an exceedingly complex stereochemic system as the germplasm, it follows that the germplasm must be extremely sensitive to changes in internal and external conditions, and that its operations and products may be so materially modified by changes in its molecular arrangements or components as to give rise to variables that are manifested in the transmutability of sex, variations, fluctuations, mutations, deformities, retrogressions, tumor formation, immunities, etc.

Assuming in accordance with our conception that the germplasm is in its incipiency an unequilibrated stereochemic system that is characteristic of the inherent, fundamental stereochemic system of the parent, it follows, as a corollary that, having a highly specialized form of parental structural material with peculiar energy-properties, the offspring must of necessity possess essentially the same fundamental characteristics as the parents when normal fecundation has occurred, and that it would be quite as impossible to have any other result than in ordinary chemical reactions under given conditions of experiment. The essential characters of the building material as regards substances, arrangements and energy-properties are definitely fixed within narrow limits of variation.

That the peculiar forms of stereoisomerides, or intimately related bodies that are inherent in the parent are conveyed in the germplasm to the offspring, and hence of necessity serve to distinguish a given form of germplasm from that of any other species or genus, and that the stereochemic conception of the nature of the germplasm is capable of laboratory demonstration, are instanced in the results of the investigations of Kossell and his students who found that simple forms of protein, known as protamins, obtained from the spermatozoa of different species of fish are different, each being apparently of a form peculiar to the source. Here is one substance at least that seems to be in specific stereoisomeric forms in the sperm of different species, which obviously must affect the properties of the germplasm, and which when brought in contact with the germplasm of the egg play its part in determining the phenomena of development. Moreover, by the "precipitin reaction" method Blakeslee and Gortner have found evidence that is consistent with the conclusion that there are not only "species proteins" but also "sex proteins," and this receives support in a number of very recent investigations, especially those of Steinach, who found that the corresponding hormones secreted by the ovaries and testicles are different, and that by virtue of these differences the secondary sexual characters, female and male, are determined. Thus he found in castrated young males, in which transplantation of ovaries had been practised, that the development of masculine peculiarities is inhibited and female traits substituted, so that the individuals tend to assume the

female type and become to a striking degree feminized-males, as shown in bodily form, in a development of the mammary glands, in lactation, and in an alteration of psycho-sexual characters. Furthermore, Riddle has found that the ova of the pigeon are dimorphic, one males and the other half females; that the eggs having the male tendency have a higher per cent. of water, a smaller size, and a lower half having an inherent tendency to produce males and the other half females; that the eggs having the male tendency have a higher per cent. of water, a smaller size, and a lower per cent. of potential energy; and that the "sex-foundation" of the germplasm is transmutable, so that an egg that has inherently the male tendency may become female, and that such females exhibit secondary male sexual characters. The transmutability of the germplasm is comparable in its physico-chemical mechanism to the reversion of the maltose-dextrose-maltase reaction that is caused by a change in concentration of the solution, the dextrose being reverted into isomaltose and not to the antecedent maltose—the male egg is not changed into a female egg, but into a modified or feminized-male egg.

In considering the transmissibility of parental substances it is essential to distinguish positively between the stereoisomerides and intimately related bodies that are *inherent* in the parent and those which are *acquired* through infection or otherwise. Thus antibodies that are acquired by the mother may be without influence upon the ovary during the formation of the germplasm and not even become a constituent of the latter. On the other hand, an immunity may be established in the mother that may be conveyed to the offspring, yet, curiously enough, such an immunity may not be transmitted by the immunized male. In processes of the production of the germplasm the ovary may be as insensitive to the presence of many acquired substances of the blood as are some or all other organs, and there is no more reason in general for expecting the ovary and its product to be affected by such bodies or conditions than there is for the pancreas and the pancreatic juice or any other secretory structure and its product to be affected. Every acquired substance must in its relations to the ovaries be governed by the same physico-chemical laws as determine specific selectivities or reactivities in connection with the tissues generally. Hence, any such substance may be reactive in relation to one structure, but not to another.

Plasticity as regards sex-determination has been demonstrated in the studies of the development of a male (drone) bee from the unfertilized egg, and of a female from the fertilized egg. Moreover, the developing female bee when fed on ordinary food becomes a common female "worker," but when fed on royal food develops into a queen.

The *continuity of the building material* between parent and offspring is seen in its simplest manifestations in reproduction among protozoa by binary fission and budding, by which the part separated from the parent mass is in all essential respects like the parent, having the same fundamental physico-chemical composition and constitution. That in such instances the offspring should be a segmental counterpart of the parent mass seems as obvious as that halves of a cube of sugar should be alike. Similarly, if we have in the ovule and sperm forms of protoplasm which as stereochemic systems are in all fundamental respects counterparts of those from which the parents were developed, it follows that the offspring must under normal conditions in accordance with the laws of physical chemistry have the same fundamental parental characteristics, as much so as separated portions of any complex stereochemic system must possess the properties of the initial mass. Moreover, if the stereochemic systems of germplasms of the female and male differ, as must be admitted, it is manifest that the stereochemic system of the egg that has been activated artificially or naturally, as the case may be, must be different, and hence undergo development differences that will be obvious in the offspring. In the first instance, the serial reactions which lead to the formation of the different tissues, etc., are activated by a mere disturbance of physico-chemical equilibrium, which may be due to the conversion of a proenzyme into enzyme or a prosecretin to a secretin, or in

other words of an inactive body into an active one. In the second instance, there is not only activation, but the extremely important addition of the male stereochemic system which by admixture with the female system constitutes a female-male system. Therefore, in the first place the offspring is developed solely from the female stereochemic system, and in the second place from the combined female and male systems, one or the other of which may be wholly or in part dominant in determining certain peculiarities in the developmental changes. Moreover, owing to the transmutability of stereoisomerides and the multiphase transmutability of stereochemic systems, coupled with the reversibility of metabolic processes which may be due to even the simplest of changes in physico-chemical mechanisms, we have a logical basis for the explanation of the phenomena of sexual dimorphism that is expressed in the so-called male and female ova, and male and female spermatozoa; of primary and secondary hermaphroditism; of paradoxical sex developments where the unfertilized egg develops into either male or female offspring; and of sexual transmutability of the inherently male or female ovule.

It follows upon the basis of our theory that because of the inherent peculiarities of the stereochemic systems of the germplasms and the definitely predetermined nature of the entire series of reactions in accordance with the laws of physical chemistry that "like begets like" because like every other physico-chemical phenomenon, individual or serial, under given conditions, it is *a physico-chemical fatality.*

Edward Tyson Reichert
University of Pennsylvania

THE CONTENT AND STRUCTURE OF THE ATOM[1]

This lecture has presented to you a vision of the recent struggle toward a better knowledge of the atom. Both experimental results and theory have been briefly discussed. You can readily place confidence in the former, but in the realm of theory you are unable to distinguish truth from error. I have brought to you, then, not the satisfaction which one enjoys in believing he hears the final truth, but rather the discontent with which the scholar views the limitations of knowledge in his field. Such discontent gives birth to zealous endeavor to learn new truth and is thus the precursor of that research in science which our society is organized to encourage. An attempt to think in sub-atomic terms very quickly makes one conscious of the limitations of our knowledge. But I wish to emphasize that such limitations occur in all sciences and, indeed, at any point that a scholar chooses to make his special study. These limitations are not usually easy to extend, especially in the older sciences. And just such difficulties furnish the challenge of scholarship in science to the young men and young women of ability.

There is, however, no need to offer explanations to those who are dissatisfied with a discussion in which truth and error can not be separated. The unscientific mind possesses but two compartments, one for truth and one for error, and such a mind has no compartment in which to place a discussion of the nature and structure of an atom. The scientist, however, recognizes no such compartments, for absolute truth and absolute error are unknown to him. After weighing the evidence furnished, his decisions consist only in selecting the degree of his confidence that is merited by that evidence.

Having given you a bird's-eye view of the evidence, it may now be appropriate to present a brief résumé in perspective of the great achievements in science which have been the subject of this lecture. We can now regard the existence of the sub-atomic electron with as much confidence as that given any other experimental fact in physics. There is yet a question as to whether or not the electron actually is our smallest unit of negative electricity, but the affirmative evidence is much the greater. The mass of the electron can be called "apparent," with the restriction that we know this to be true only to the de-

[1] The closing portion of the address of the retiring President of the Iowa Chapter of Sigma Xi, delivered on October 14th.

gree of accuracy of the experiments. But one can be fairly confident as to the electrical character not only of the electron, but also of the entire atom, for there is much evidence in favor of such a view and none that is contradictory. The conception of a nucleus, as given in the Rutherford theory, is so well verified in the experiments in the deflections of the alpha-particles, the velocity of the struck atom, and the high frequency spectra and in the splendid use made of it by Bohr's theory, that it will probably remain, suffering but little change in the future. It is reasonable to believe that the charge of the nucleus is a natural atomic unit, supplanting the atomic weight in determining the position of an element in the Periodic Table, as now understood. This suggested important function of the nucleus charge seems to afford an explanation for the existence of "isotopes," or elements occupying the same position in the Periodic Table, possessing the same chemical properties and giving the same spectrum, but exhibiting different radio-activities. Moreover, it is becoming more evident that our conception of the atomic weight as a natural unit is incorrect, that the atomic weight is merely the resulting apparent mass of the atom, or practically of the nucleus, and that this apparent mass is not merely the sum of the apparent masses of the charges in the nucleus considered separately, for the apparent mass of a charge is influenced by the proximity of other charges.

The very valuable theories of atomic structure, especially that of Bohr, can not, of course, command one's complete confidence. Indeed, Bohr's theory has been extended to but a partial investigation of the simplest elements and does not pretend to be complete. It possesses great interest because it is a relatively simple effort to account for the exceedingly complex functions of the atom. At the present stage of development of this theory its chief faults are the questioned validity of its assumptions, its lack of uniqueness, and the impossibility of extending it to complex atoms. The question of the validity of the assumptions involved should not be taken too seriously, for any assumptions that will lead to an agreement of theory and experiment will be welcome. The lack of uniqueness need not be a matter of immediate concern, for experimental facts at the present time go far beyond any suggested theory. There is, however, a strong contention on the part of Nicholson that the present theory of Bohr can not be extended to more complex atoms without marked modifications in the present assumptions. But the theory is a remarkable contribution even if it does no more than explain many facts known in the case of the simplest elements. When one contemplates the narrow scope of even this brilliant theory, what a limitless field for research seems ahead! Fortunately, there are at hand a number of methods of investigation that have not yet been fully utilized. Some of the most promising lines of research in this field are the extension of theory into the fields of heat radiation and magnetism and to a larger number of elements, the study of high-frequency spectra, the scattering of swift β particles, the production of Röntgen rays by the impact of positive rays, the low temperature characteristics of elements, and the effects of the magnetic and electric fields upon line spectra. To this might be added a long list of experiments which are more indirect, but which, nevertheless, are very important. An illustration is the investigation of the electrical and optical properties of selenium crystals, which is now being carried on in the laboratory of this university by Doctors Brown and Sieg. Before all these lines of approach are fully occupied new ones will be found, and there is no indication of a cessation of the attack upon the atom for years to come.

Where will the investigation end? It will be without end. Notwithstanding the prospect of such a lively attack upon this problem, one can readily appreciate that progress is likely to be made with much difficulty, taxing all the resources of the physicist and the mathematician. Yet science rarely completes a task before new problems that are more fundamental are found. For example, electricity was first discovered as electrification or strange vari-

ations of matter. The problem of matter was not solved before that of electricity was undertaken. Indeed, through the study of this variation in matter we came to appreciate that in it lay the path to the understanding of the atom. Will this experience now be repeated? Will a variation in the electron, not accounted for by electrical laws, be found, and will an investigation of that phenomenon lead to knowledge of the electron and thus of the atom?

I now desire to direct the attention of the younger members of the Society to two significant points that are illustrated by the material in this lecture. The first is that a problem may be too difficult for a direct attack, and one may need to await discoveries which furnish new and unsuspected clues. Röntgen rays were not discovered for the purpose of studying atomic structure. Neither was such a purpose the cause of experiments which led to the discovery of radioactivity. Thus the scientific worker can never know the future importance of his own work. His motive should be to follow up the most promising clues with which he is favored and to trust that all he accomplishes will be worthy of his effort.

The second point is suggested by the fact that most of the methods of attack here mentioned are comparatively new and probably will never become part of laboratory technique taught in a university curriculum. Method in scientific research is fundamentally not a thing to be learned by graduate or research students. For scientific research is nothing more than the successive application of complete acts of thought to experimental and theoretical problems. One needs but to think and to act.

G. W. Stewart
State University of Iowa

METHODS OF RESUSCITATION

In line with its campaign to reduce the number of deaths in the mines of the United States, the Federal Bureau of Mines some time ago appointed a committee of eminent physicians and surgeons to develop an efficient method of resuscitation to be administered by miners or other persons to a fellow-workman overcome by electric shock or by gases in places which can not be reached by a physician or surgeon in time to save life.

As a result of this committee's report just made, the Bureau of Mines, through Director Joseph A. Holmes, recommends the following procedure in rendering first aid to those in need of artificial respiration.

The recommendations apply not only to men who are overcome by electric shock or gases in mines, but also to persons suffering from the effects of illuminating-gas poisoning or from electric shock anywhere. The recommendations are, therefore, of importance to many thousands of workmen:

In case of gas poisoning, remove victim at once from the gaseous atmosphere. Carry him quickly to fresh air and immediately give manual artificial respiration. Do not stop to loosen clothing. Every moment of delay is serious.

In case of electric shock, break electric current instantly. Free the patient from the current with a single quick motion, using any dry non-conductor, such as clothing, rope, or board, to move patient or wire. Beware of using any metal or moist material. Meantime have every effort made to shut off current.

Attend instantly to the victim's breathing. If the victim is not breathing, he should be given manual artificial respiration at once.

If the patient is breathing slowly and regularly, do not give artificial respiration, but let nature restore breathing unaided.

In gas cases, give oxygen. If the patient has been a victim of gas, give him pure oxygen, with manual artificial respiration.

The oxygen may be given through a breathing bag from a cylinder having a reducing valve, with connecting tubes and face mask, and with an inspiratory and an expiratory valve, of which the latter communicates directly with the atmosphere.

No mechanical artificial resuscitating device should be used unless one operated by hand that has no suction effect on the lungs.

Use the Schaefer or prone pressure method

of artificial respiration. Begin at once. A moment's delay is serious.

Continue the artificial respiration. If necessary, continue two hours or longer without interruption until natural breathing is restored. If natural breathing stops after being restored, use artificial respiration again.

Do not give the patient any liquid, until he is fully conscious.

Give him fresh air, but keep his body warm.

Send for the nearest doctor as soon as the accident is discovered.

The members of the committee reporting to the Bureau of Mines are as follows: Dr. W. B. Cannon, chairman, professor of physiology, Harvard University; Dr. George W. Crile, professor of surgery, Western Reserve University, Cleveland, Ohio; Dr. Joseph Erlanger, professor of physiology, Washington University, St. Louis; Dr. Yandell Henderson, professor of physiology, Yale University; and Dr. S. J. Meltzer, head of the department of physiology and pharmacology, Rockefeller Institute for Medical Research.

AWARDS OF THE JOHN SCOTT MEDAL

The city of Philadelphia, acting on the recommendation of The Franklin Institute, has awarded the John Scott Legacy Medal and Premium to Elmer Ambrose Sperry, of New York, N. Y., for his gyro compass. On battleships under action, the shifting of large masses of magnetic material precludes the use of the magnetic compass, and even on ordinary iron vessels, the material of the ship and its disposition must be compensated for. The gyro compass is entirely non-magnetic and is unaffected by the proximity of iron. For some years Mr. Sperry has devoted practically his whole time to overcoming the numerous physical difficulties involved in the adaptation of a gyroscope to a ship's compass in the place of a magnetic needle. He has been able to make an instrument which automatically corrects for the speed and direction of the vessel, and which is unaffected by the rolling of the ship in a heavy sea. His compass may be made in the form of a master compass which may be made to actuate secondary or repeater compasses mounted in any desired part of the vessel. On naval vessels, such an arrangement is very desirable, as the master compass may be installed behind heavy armor plate and protected from damage, and may still be available when all the secondary compasses are destroyed.

An award of the John Scott Legacy Medal and Premium has also been made to Arthur Atwater Kent, of Rosemont, Pa., for his "unisparker." The unisparker is an essential element of the Atwater Kent Ignition System for automobiles, and consists of a contact-breaker, governor and distributor, arranged in one structure. The contact-breaker is in the primary of a non-trembler coil circuit and is so designed as to be operative only when the engine runs in one direction, thus preventing backfiring. The governor automatically advances and retards the spark according to the requirements of the engine. The distributor is in the secondary circuit of the coil and distributes the sparks to the several cylinders. All the parts of the device are especially designed for durability. The contact points are of tungsten and are of large area. The current in the primary circuit can be reversed at will, changing the polarity of the contacts and preventing their disintegration.

PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES

In January, 1915, the National Academy of Sciences will begin the publication of Monthly Proceedings. The members of the editorial staff, with the fields of science represented by them, are:

Astronomy: E. B. Frost, Yerkes Observatory, Williams Bay, Wis.

Mathematics: E. H. Moore, University of Chicago, Chicago, Ill.

Physics: Henry Crew, Northwestern University, Evanston, Ill.

Chemistry, Biological and Organic: J. J. Abel, Johns Hopkins University, Baltimore, Md.

Chemistry, Physical and Inorganic: A. A. Noyes, Mass. Inst. Tech., Boston, Mass.

Geology: H. F. Reid, Johns Hopkins University, Baltimore, Md.

Paleontology: Charles Schuchert, Yale University, New Haven, Conn.

Botany: J. M. Coulter, University of Chicago, Chicago, Ill.
Zoology: R. G. Harrison, Yale University, New Haven, Conn.
Genetics: C. B. Davenport, Cold Spring Harbor, N. Y.
Physiology: W. B. Cannon, Harvard University, Cambridge, Mass.
Pathology: Simon Flexner, Rockefeller Institute, New York City.
Anthropology: W. H. Holmes, National Museum, Washington, D. C.
Psychology: J. McKeen Cattell, Columbia University, New York City.
Ex-officiis:
Home Secretary, A. L. Day, Geophysical Laboratory, Washington, D. C.
Foreign Secretary, G. E. Hale, Solar Observatory, Pasadena, Cal.
Managing Editor: E. B. Wilson, Mass. Inst. Tech., Boston, Mass.
Chairman of the Board: A. A. Noyes, Mass. Inst. Tech., Boston, Mass.

The main purpose of the proceedings is to obtain the prompt publication and wide circulation of a comprehensive survey, in the form of brief original articles, of the more important scientific researches currently made by American investigators. The articles are to be much shorter and less detailed than those commonly published in special journals, and may subsequently be published in more extensive form in such journals. It is expected that the articles will as a rule vary from one to five printed pages in length, with a maximum limit of eight to ten pages in exceptional cases where the results of extended investigations are summarized, or the significance of a series of detailed publications is formulated. The articles are, however, to be precise, and to contain some record of the experimental, observational, or theoretical methods and results upon which the conclusions are based; but these statements are to be condensed, long tables of data and the details of the work being reserved for publication in special journals.

SCIENTIFIC NOTES AND NEWS

THE Bisset Hawkins memorial medal, awarded triennially by the Royal College of Physicians of London, in recognition of work in advancing sanitary science or promoting public health during the preceding ten years, was, on October 19, presented to Sir Ronald Ross, in recognition of his researches on malaria.

THE Technical Institute at Zurich has conferred its honorary doctorate on Professor Hermann Schwartz, professor of mathematics at Berlin, on the occasion of the fiftieth anniversary of his doctorate.

DR. JOSEPH P. IDDINGS is engaged in geological research in the far east, having been in Java in August. He does not expect to return to Washington for a year or more.

DR. J. WILLIAM WHITE, emeritus professor of surgery at the University of Pennsylvania, and Dr. R. Tait McKenzie, head of the department of physical education, have volunteered their professional services to the British government.

MR. MILLARD K. SHALER, who is representing the United States in affording relief to suffering Belgians, was, until 1909, a member of the U. S. Geological Survey, since which time he has been engaged in explorations in the African Congo region.

SEVERAL German scientific men, including the botanist Dr. Kukenthal, who were engaged in a scientific expedition to Corsica, are said to be held prisoners of war on the island.

DR. R. TRUMPLER, astronomer for the Geodetic Commission of Switzerland, has been appointed assistant at the Allegheny Observatory, but has thus far been detained, being an officer in the Swiss army.

DR. GEORGE H. SHULL has returned to the Station of Experimental Evolution, Cold Spring Harbor, N. Y., after spending thirteen months in Berlin. He carried on some experiments in Dr. Erwin Baur's botanical garden in Friedrichshagen, and at the outbreak of the war was able to assist in the other experimental work. Previously he took part in the meeting of the German Botanical Society, and by invitation gave an address on heterozygosis in its bearing on practical breeding before the Society for the Advancement of

German Plant Culture at its annual meeting, held this year at the University of Göttingen.

Dr. A. M. Patterson has resigned as editor of *Chemical Abstracts*, and Dr. J. J. Miller has been elected editor and Dr. E. J. Crane, associate editor of the publication.

On November 1, Dr. C. W. Stiles changed stations from the U. S. Marine Hospital, Wilmington, N. C., back to the Hygienic Laboratory, Washington, D. C. His address until further notice will be: Hygienic Laboratory, 25th and E Streets, N. W., Washington, D. C. All communications intended for the International Commission on Zoological Nomenclature should be sent to that address.

Dr. Harvey W. Wiley celebrated his seventieth birthday on October 18 by a dinner party, the guests at which included Professor Charles E. Monroe, who was one of Dr. Wiley's instructors at Harvard University; Dr. W. D. Bigelow, for many years associated with Dr. Wiley in the bureau of chemistry; Dr. G. L. Spencer, who was a student under Dr. Wiley when he taught at Purdue University 40 years ago, and who is widely known as a sugar engineer, and Professor Frank W. Clarke, of Washington.

In recognition of his work on the fossil birds in the collection of the Peabody Museum of Yale University, Dr. R. W. Shufeldt, of Washington, D. C., was, at the regular meeting of the Connecticut Academy of Arts and Sciences held on October 28, elected an active member of that society. The society has accepted for publication the aforesaid work, it being a description of the fossil birds in the Yale collection, including a revision of all of Professor O. C. Marsh's types (exclusive of the *Odontornithes*), and other material left undescribed by him. Several new genera and species of extinct birds are described for the first time.

Dr. Irwin Shepard, for twenty years secretary of the National Education Association, has for the past fifteen months been connected with the Panama-Pacific International Exposition as national secretary of the bureau of conventions and societies. He has been associated with James A. Barr, director of congresses, in the work of arranging for a world series of congresses, conferences and conventions. On September 11, he was compelled for reasons of health, much to the regret of the exposition authorities, to retire from the active work of the bureau.

A series of lectures on "Sanitation as Applied to Cities" is being given at the Worcester Polytechnic Institute on Monday and Friday afternoons during November by Professor George C. Whipple, of Harvard University. The dates and subjects of the lectures follow:

November 2. "The Value of Municipal Cleanliness."
November 6. "Clean Air."
November 9. "Clean Water."
November 13. "Disposal of Liquid Wastes."
November 16. "Disposal of Solid Wastes."
November 20. "The Economics Factor in Sanitation."
November 23. "The Social Factor in Sanitation."

A course of eight public lectures is being given in the botanical department of University College, London, on the rôle of plants in the protection and growth of the shore, by Professor F. W. Oliver.

The Harveian Oration, delivered before the Royal College of Physicians of London on October 19 by Sir R. Douglas Powell, dealt with advances in knowledge regarding the circulation and attributes of the blood since Harvey's time.

On October 30, Professor J. C. Bose, of Calcutta, gave a lecture before the Royal Society of Medicine, London, on the modification of response in plants under the action of drugs.

The second Thomas Hawksley lecture was delivered in the meeting hall of the Institution of Mechanical Engineers on October 30, by Mr. W. B. Bryan, the subject being "Pumping and Other Machinery for Waterworks and Drainage."

The family of Emil du Bois Reymond has donated the Helmholtz gold medal to the relief fund, with the statement that this medal, repre-

senting the highest appreciation in his own land of the scientific achievements of du Bois Reymond, is honored more by devoting it to the service of the country than by preserving it.

WE learn from *Nature* that the opening meeting of the new session of the Institution of Electrical Engineers, London, will be held on Thursday, October 29, when the president, Sir John Snell, will deliver his inaugural address. At this meeting a marble bust of Michael Faraday will be presented to the institution by Mr. Llewellyn Preece, on behalf of the family of the late Sir William Preece, past president.

DR. GEORGE LIVINGSTON PEABODY, formerly a prominent New York physician, died suddenly at his home in Newport on October 30. Dr. Peabody, who was in his sixty-fifth year, graduated from Columbia College in the class of 1870, and from its College of Physicians and Surgeons in 1873. He was lecturer in medicine in the college from 1884 until 1887, and then became professor of materia medica and therapeutics, which post he held until 1903.

DR. FREDERICK KÖNIG, professor of surgery at the university of Marburg, was killed recently while attending to the wounded on one of the battlefields at the eastern seat of war. Others who have lost their lives in the war are Dr. Ernst Preuss, docent for machine-testing in the Technological School at Darmstadt, and Dr. Wilhelm Deimler, docent for mathematics in the School of Technology at Munich.

THE directors of the American Chemical Society have voted that it is not advisable to hold any general meeting of the society previous to the New Orleans meeting, April 1–3, 1915. They have also voted, in accord with previous invitations presented to the council, that the annual meeting of 1915 be held in Seattle, Washington, with adjournment to San Francisco, the exact date to be settled by the president and secretary after conference with members of the section immediately concerned.

THE office of the American Mathematical Society was destroyed by fire on October 10, with loss of records, files and a considerable part of the stock of back numbers of the *Bulletin* and *Transactions*. The society has now no copies of the first ten volumes of the *Bulletin* except the single set in its library. Gifts of any of these early volumes would be greatly appreciated, and also of any copies of the Annual Register. The society's address is 501 West 116th Street, New York, N. Y.

THE New York Section of the American Electrochemical Society will hold a joint meeting with the American Gas Institute and the Institute of Illuminating Engineers at the Chemists Club, New York, on Tuesday, November 10. An informal dinner, to which guests are cordially welcome, will be held at the Chemists Club at 7 on the night of the meeting. The program is as follows:

"The Improved Incandescent Mantle," Milton C. Whitaker, Columbia University.

"Chemistry in the Development and Operation of the Flaming Arcs," William C. Moore, National Carbon Co.

"The New Tungsten Lamps," Ralph E. Myers, Westinghouse Lamp Co.

"The Quartz Mercury Lamp," R. D. Mailey, Cooper Hewitt Electric Co.

"The New Moore Tubes," D. MacFarlan Moore, Edison Lamp Works.

AFTER ten years of successful experience, the Mathematical Club of Syracuse University has been reorganized into a mathematical fraternity, Pi Mu Epsilon, whose aims are the advancement of mathematics and scholarship. The fraternity was incorporated under the laws of the state of New York under date of May 25, 1914. The charter members consist of members of the mathematical faculty, graduate students in mathematics and undergraduate major and minor mathematical students. Among the powers granted under the articles of incorporation is that of granting charters to other chapters to be organized elsewhere.

THE Royal Canadian Institute in Toronto, Canada, plans to inaugurate work on the lines of the Mellon Institute of the University of Pittsburgh. Dr. Raymond F. Bacon, director of Mellon Institute, has been invited to speak before the Canadian Institute this month. The University of Toronto has been selected for this meeting because the late Dr. Robert

Kennedy Duncan, founder of the system of industrial research in Pittsburgh, was a Canadian and a graduate of the University of Toronto. The Dominion of Canada Royal Commission on Industrial Research visited Pittsburgh about a year ago to study the institute. The report of the commission indicated that work such as that done by the Mellon Institute was as urgently needed in Canada as in the United States.

The surgeon general of the army announces that preliminary examinations for appointment of first lieutenants in the Army Medical Corps will be held on January 11, 1915, at points to be hereafter designated. Full information concerning these examinations can be procured upon application to the "Surgeon General, U. S. Army, Washington, D. C." The essential requirements to secure an invitation are that the applicant shall be a citizen of the United States, shall be between 22 and 30 years of age, a graduate of a medical school legally authorized to confer the degree of doctor of medicine, shall be of good moral character and habits, and shall have had at least one year's hospital training as an interne, after graduation. The examinations will be held simultaneously throughout the country at points where boards can be convened. Due consideration will be given to localities from which applications are received, in order to lessen the traveling expenses of applicants as much as possible. In order to perfect all necessary arrangements for the examinations, applications must be completed and in possession of the adjutant general at least three weeks before the date of examination. Early attention is therefore enjoined upon all intending applicants. There are at present twenty vacancies in the medical corps of the army.

A valuable collection of ethnological specimens has just been received by the University of Pennsylvania Museum from Dr. William C. Farabee, who is at the head of the university's Amazon expedition. The specimens were collected in the southern part of British Guiana among the Carib and Arowak Indians and other hitherto unknown tribes. They include clothing for men and women, made from the feathers of the Macaw and other birds of rich plumage, paintings of religious ceremonials, on sticks, beadwork, bows and arrows, spears, hammocks and domestic utensils.

Miss Sue Watson, of Pittsburgh, artist of the department of anatomy in the School of Medicine, University of Pittsburgh, has been appointed by Governor John K. Tener, to make four panels, which will stand above the main entrance of the Pennsylvania State Building at the Pan-Pacific Exposition. This is the second award that Miss Watson has received for public work of this kind, the first one having been the award for decorative work on the new Schenley Theater.

The Royal Photographic Society has, as we learn from *Nature,* opened to the public a house exhibition of photographs by Mr. Lewis Balfour, "Bird Life on the Bass Rock." There are upwards of one hundred of these pictures showing the various sea birds and incidents in their lives.

A movement has been set on foot in Holland for a resumption of scientific exploration in the Dutch East Indies, in the region between Celebes and New Guinea, particularly in the island of Ceram. At the end of last year the matter was referred by the president of the Royal Netherlands Geographical Society to the Expedition Committee, which, after fully considering the question, reported to the Council of the Society in March, 1914. The committee, which included various gentlemen who have taken part in previous scientific research in that region, enjoyed the cooperation of other experts, and from a study of all existing information, drew up a statement on the present state of our knowledge of the part of the Archipelago between Celebes and New Guinea, which is considered to offer an important field for further research. This statement, together with the report of the committee, is taken by the *Geographical Journal* from the May number of the *Tijdschrift* of the Netherlands Geographical Society. As regards the large island of Ceram, it is pointed out that existing knowledge of its topography is scanty, and, for the interior of the eastern part, practically nil.

From a geological point of view much valuable information would result from a study of the double bridge of islands between Celebes and New Guinea—the more northerly running through Pulo Peling, the Banggai archipelago, the Sula Islands, Pulo Obi and Misol, to the so-called "duck-bill" of New Guinea; the more southerly through Buru and Ceram to Fakfak. This is, in fact, one of the most important and interesting tasks remaining to be done in the archipelago. A detailed examination of the geology of Ceram, known to us only through the work of Martin and Verbeek, would be of both scientific and practical value. In the domain of hydrography and oceanography there is much to be learned in the region round Ceram, and the program would include surveys, soundings, studies of the tides, currents, temperature and composition of the water, and the fauna and flora of the coast, the coastal waters, and the deep sea. Little is also known of the inhabitants of the interior of Ceram, their relationships among themselves and with the coast peoples, their languages, and so on. The zoology and botany of the island offer a wide field for research, and in conjunction with the geology should throw an important light on the past history of this part of the world. The flora of Central Ceram is considered to be probably the oldest member of the flora of the Moluccas. The proposed investigations promise results of great scientific interest.

THE United States Geological Survey has just printed a large, colored wall map showing the petroleum resources and the natural gas deposits of the United States, and also the thousands of miles of trunk oil pipe lines. The map shows the areas underlain by known oil pools and known gas pools, as well as general localities which are productive in either oil or gas, and also areas where there are noteworthy occurrences of either oil or gas but where there is no present production. The map is 49 by 76 inches, printed on the scale of 40 miles to 1 inch, in 5 colors. It is printed in two sheets and is sold by the Geological Survey. This map not only shows graphically the oil fields and pipe lines, but is an excellent general map of the United States.

UNIVERSITY AND EDUCATIONAL NEWS

A GIFT of $10,000 has been made to Brown University from the Philadelphia alumni for the purpose of establishing the "Morgan Edwards Fellowship."

THE council of the University of Paris has made all arrangements for beginning courses in the various departments at the usual date.

THE St. Louis College of Pharmacy will celebrate its semi-centennial on November 10 and 11, with appropriate exercises, participated in by prominent pharmaceutical educators from different sections of the country.

THE extension of the certificate privilege to accredited high schools and preparatory schools has resulted in an increase in the number of students in the freshman class entering Stevens Institute this fall of eighty-three per cent. over the number entering last year.

DR. WALTER PEARSON KELLEY has been appointed professor of agricultural chemistry in the graduate school of tropical agriculture and citrus experiment station of the University of California. Woodbridge Metcalf has been appointed assistant professor of forestry in the university, and Dr. Wilbur A. Sawyer, director of the California State Hygiene Laboratory, has been appointed lecturer in hygiene and preventive medicine in the medical school.

DR. CORNELIUS COPLEY has been appointed professor of laryngology in the College of Physicians and Surgeons, Columbia University, to succeed the late Dr. William K. Simpson.

MR. M. A. CHARAVAY, instructor in experimental engineering, in the Stevens Institute of Technology, has been appointed assistant professor. Mr. C. Lester Coggins, of the department of physics has accepted an assistant professorship at Rhode Island State College. Mr. L. C. F. Horle, a graduate of Stevens, has been appointed assistant in physics in his place.

DR. HOWARD THOMAS KARSNER, B.S., M.D. (Pennsylvania), now assistant professor of pathology in Harvard Medical School, has been appointed professor of pathology in the school of medicine, Western Reserve Univer-

sity, and will begin his duties December 1, 1914. The following additional full-time instructors began service this year: Henry O. Feiss, A.B., M.D. (Harvard), D.Sc. (Edinburgh), in experimental medicine; Gaius E. Harmon, M.D. (Boston), C.P.H. (Mass. Inst.), in hygiene; Bradley M. Patten, A.B., Ph.D. (Harvard), in histology and embryology; George E. Simpson, B.S. (Illinois) in organic and biochemistry.

The following appointments have been made in the department of psychology at the University of Illinois: Dr. Homer B. Reed, instructor; Dr. Joseph E. De Camp, assistant; Miss Anna Sophie Rogers, graduate assistant, and Miss Helen Clark, fellow.

Dr. Rudolf Rothe, professor of mathematics in the Technical School at Hanover, has been called to the Technical School at Charlottenburg to succeed the late Professor Hettner.

Dr. Peter Debye, professor of physics at Utrecht, has accepted a call to Göttingen.

DISCUSSION AND CORRESPONDENCE

THE HISTORY OF SCIENCE

To the Editor of Science: During the past months I have written a number of professors, deans and college presidents, as well as directors of institutes of technology, in reference to the value to American undergraduates of the study of the history of the sciences and industries. In each case the response received has been marked by cordiality and enthusiasm; so that I am now encouraged to seek a larger audience than can be reached by private correspondence. May I hope that the columns of your periodical will be open for a discussion of the matter?

Many of my correspondents (whose names, unfortunately, I have not yet sought permission to quote) feel that if in their undergraduate days they had been given a survey of the development of the sciences, or, better still, had been led to trace the evolution of scientific thought, their individual mental progress would thereby have been much stimulated and advanced. They feel, moreover, that such a course of study as I suggest would be of special value in America, where our life and institutions commit us to the ideals of a democratic culture.

It is of course widely recognized that the individual sciences would be better taught if presented on an historical background; we know most vividly what we know in its origins. An old-fashioned course in chemistry taught us that oxygen was a colorless, tasteless, odorless gas, non-combustible, but a supporter of combustion, and left it to later chance reading to disclose the thrilling story of the discovery of oxygen. Those fortunate enough (perhaps years after graduation) to read eventually of the men of genius, Scheele, Priestley, Lavoisier, who had agonized to attain the generalization that had seemed so tame and valueless to the undergraduate, realized the defectiveness of instruction that sought to give the results of scientific investigation without availing itself of the historical motive.

The practise of teaching the sciences in their evolution is a needed modification of Herbert Spencer's pedagogy, without which his theory is both inconsistent and rude. On the one hand, he, like a true follower of Auguste Comte, held that the development of the individual intellect should rehearse the course of the history of civilization; on the other hand, he attacked as too primitive what he called the esthetic and ornamental studies. If he had supplemented his devotion to the sciences (as he understood them) by a recognition of the sciences in their development he would have been more consistent, and perhaps have been less bellicose in his attitude toward those languages in which Archimedes, Lucretius and Galileo wrote. That the history of the sciences was the essential history of civilization and as such should be rehearsed by each developing mind he still could have maintained.

Another defect in the undergraduate curriculum that might be made good by the general history of science is the lack of connection between scientific studies. In the old-fashioned college the student was permitted to take up biology in the freshman year, phys-

ics and chemistry in the sophomore, mineralogy and crystallography in the junior, and geology, astronomy and psychology in the senior. Scarcely a word in reference to the mutual influences and interconnections of these sciences! Only the exceptional graduate was able to bring order out of the chaos of knowledge he bore away with his skeepskin.

Those who attend American institutions of higher learning might easily be made to see in the beginnings of science essential problems in their less complex forms, and realize that organized knowledge arose in connection with industry and human needs. They could be placed in a position to appreciate the present-day applications of science, and to welcome future inventions and discoveries. At the same time they would learn that some of the most abstract reasoners have contributed to racial progress through studies that were not obviously utilitarian. They could be made to understand that science is the constant pursuit of truth and not merely a treasure-house of truth already attained, and incidentally that it is no reproach to science that it does not teach to-day what it taught five hundred years ago, and that Darwin did not live in vain even if what he discovered is also in the process of evolution. As already indicated, our undergraduates through the example of the great scientists should be stimulated to research and independence, and weaned from the childlike notizenstolz of the academic classroom.

Of course in order to be truly cultural a course in the history of the sciences must rise to general ideas, discuss cause and effect, the constitution of matter, and the conceptions fundamental to all the sciences. In a word it must be interpretive and not merely narrative. In fact, the subject of study I am discussing first presented itself to my mind as an equivalent in this institution of the traditional history of philosophy, a means of deepening our culture without prejudice to our confessed practical, vocational aims. It was soon realized that the general history of science affords a unique approach to the history of general thought. The history of philosophy can be reread in the light of the history of science.

For example, we all learned at college that Thales saw in water, or the moist, the principles of all things; but we were not taught at the same time that twenty-three centuries elapsed before men discovered the constitution of water as we understand it, and before it was demonstrated that water could not be reduced to a solid by boiling; that Thales was dealing with what a later time called the states of aggregation of matter; and that liquid, or possibly fluid, might represent his conception. Similarly we studied the theory of the pneuma without knowing that it was late in the eighteenth century that a great chemist published his "experiments and observations on different kinds of air." The nature of the elements, the reality of the concept, the permanence of species, the transmigration of souls and genetic psychology, these topics will suggest to my readers points at which the history of science throws light on the history of philosophy. Indeed whole periods, like the scholastic (with its insistent question: What is the difference between this and that?), assume a new value as seen from the standpoint of the history of science.

Dannemann's work "Die Naturwissenschaften in ihrer Entwicklung und in ihrem Zusammenhange" has the merit of offering a wealth of material on the subject it treats. The fourth volume gives excellent bibliographies of the general history of the sciences, as well as of astronomy, physics, chemistry, mineralogy, geology, zoology, botany, general biology, medicine and hygiene, technology, mathematics, etc. It is far from being an ideal text-book, but it affords a fascinating survey and leaves no doubt in the mind of the experienced instructor that the history of the sciences could be treated in a way highly acceptable to the American undergraduate. It would interest the humblest intelligence, and stimulate the exceptional minds to the heights to which they might be capable of attaining. The tactful instructor would emphasize the narrative or interpretative factors, the practical or philosophical aspects, of the subject, ac-

cording to the abilities of the students. I can think of no better means than that which the history of general science affords of making the accumulated wisdom of the race tell on the active American life of to-day.

The problem of presenting this subject adequately would be greatly simplified if there were in English a good book of four or five hundred pages on the Evolution of Scientific Thought. Let us add, since we are merely expressing a pious wish, that it should be a model of concise and logical exposition written with the charm and lucidity of a Huxley. It should rest on a background of general ideas, and be a philosophy of the sciences; at the same time it should not neglect the applications of science, and should incite an interest in industry and invention.

Some such work is needed by the scientific world as a sort of confession of faith, or canon of the truth it holds and teaches. Without some summary of what investigation has demonstrated the professor has less authority than the clergyman in the minds of young men and women. He is held in general to be an unbeliever, because he is negative rather than positive, destructive rather than constructive, a cold critic of what others teach rather than an enthusiastic exponent of the faith he holds. The professors fail to express what they really think and feel. The mind of the learned world has traveled far from the agnosticism of the middle of the nineteenth century. It is not merely that in reference to traditional faiths scholars do not believe, or believe not; they believe something else. It is too general to say that they believe in education and enlightenment and simple goodwill. It is merely intellectual to proclaim: I believe in the law of gravitation, the nebular hypothesis, the circulation of the blood, the cellular structure of the tissues, organic evolution, the continuity of germ-plasm, the dependence of human thought on nerve tissue, the evolution of mind, and the cure of disease through the development of antitoxins. But when hundreds of such truths are presented historically as the fixed points in a cosmos established by the combined efforts of men, the cumulative effect is to take us beyond a cold intellectual formulation of an ordered universe to an enthusiastic affirmation of the reign of law to be widened by the energies of the generations. Moreover, within its scope come social and ethical as well as physical and other mental phenomena, and through the historical study of ethics and sociology the student is led to see the gradual triumph of beneficent customs and legislation, supported on principles of justice, equity, freedom and good will.

Such a philosophical summary of the history of science introducing the best minds of the continent, perhaps the foremost million of the population, to the vital ideas of the time, seems an almost imperative need of American culture. For in the realm of ideas there is no such thing as spontaneous generation. Those who seem the originators of great movements are those who have been brought under great influences. Apparent exceptions to this rule, like Shakespeare or Darwin or Lincoln, prove, on examination, excellent examples. There is little difficulty in tracing historically the continuity of human thought. It follows that we can not hope for a generation of original thinkers unless we immerse our students in the stream of the world's thought. The most inventive mind must have material on which to react, and can not strike out in a vacuum.

The more or less friendly foreign critics who discuss American culture complain of our exclusive devotion to practical aims, our lack of conversation, and a certain narrowness in our outlook. From one point of view these so-called faults seem as fair as others' virtues. But it is wisdom to recognize the just element in these strictures. Practical considerations alone warn us against narrowness of training. It can be shown from a history of the industries that frequently progress has been opposed by men whose experience has confined them to one department, or to one section of one department. Advances have come here as in the sciences from outsiders. Rightly understood this is a further argument, not for lack of culture, but for breadth of culture. Such freedom of outlook, without any impair-

ment of our robust and practical ideals, can be gained by the study of the work of Faraday, Newton, Kepler, Franklin, Darwin and Pasteur, and the general conceptions on which their work was based.

In conclusion one must recognize that science is international, English, German, French, Italian, Russian, all nations cooperating in the interests of racial progress. Accordingly, a survey of the sciences tends to increase mutual respect, and to heighten the humanitarian sentiment. The history of the sciences can be taught to people of all creeds and colors, and can not fail to enhance in the breast of every young man or woman, faith in human progress and good will to all mankind.

WALTER LIBBY

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SOME INCONSISTENCIES IN PHYSICS TEXT-BOOKS

THE following is a quotation from Kohlrausch's "Physical Measurements":

> The coefficient of capillarity may be *defined* as the weight of fluid which is supported by the unit of length of the line of contact of its surface with a thoroughly wetted plate.

Now a coefficient is a proportionality factor, a pure number expressing the measure of some specified force or property. For example, the volume coefficient of expansion of a gas is the ratio between the increase in volume per degree rise in temperature, and the volume at zero degrees centigrade, the pressure remaining constant. If we keep the expression coefficient of capillarity or capillary constant it must be as the *ratio* between the weight of liquid raised above the undisturbed level and the length of the line of contact of its surface with a thoroughly wetted plate.

In my opinion there is a difficulty with ratios involving quantities measured in different units. It is much simpler, for instance, to grasp the significance of the ratio of the extension of a wire per given or unit tension, to the initial length (see Duff's "Text-book of Physics," p. 122) than of Young's modulus expressed as the ratio of the longitudinal stress to the longitudinal strain; the stress measured as tension per unit cross section and the strain as extension per unit length.

The quotation from Kohlrausch is not in any case a *definition:* it explains how the *surface tension* of a liquid may be *measured.* Capillarity is the phenomenon of rise or fall of liquids in tubes due to the surface tension of the liquids. In most recent text-books and laboratory manuals the term coefficient of capillarity, capillary constant or coefficient of surface tension is not used. Duff, for instance, and Ames in his "College Physics," state this:

> If a line be imagined drawn along the surface of a liquid, the part of the surface on one side of the line pulls on the part on the other side, and if the length of the line be supposed one centimeter the pull in dynes is taken as the magnitude of the surface tension of the liquid.

Another term used inconsistently is *specific.* A specific quantity is concrete and so should be expressed in a unit. But we find specific gavity defined as a *ratio.*

> The specific gravity of a body is the ratio of the mass of any volume of it to the mass of the same volume of pure water at 4° C. (Carhart's "College Physics"). Specific gravity may be defined consistently as the weight of unit volume of the substance (Watson's "Text-book of Physics"). But it is useful to keep in the definition, because of our methods of determining specific gravity, the idea of comparison. Kimball ("College Physics") calls it relative density, defining it as "the ratio between the density of the substance considered and the density of a standard."

The definition of the specific heat of a substance is consistently given, in most recent text-books, as the quantity of heat in calories which will raise the temperature of one gram of a substance through one degree centigrade. The specific inductive capacity of a medium is, however, defined as the ratio between the capacities of two condensers equal in size, one of them being an air condenser, the other filled with the specific dielectric. But this ratio is as often called dielectric constant, sometimes the coefficient of induction.

These points are small ones, but they are puzzling to beginners and always annoying.

SUE AVIS BLAKE

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CHEMISTRY IN THE AGRICULTURAL COLLEGE

Professor Copeland in a recent article in Science[1] on "Botany in the Agricultural College" states as a minor point that much of the chemistry taught in these institutions is not basic to work in agriculture.

It may be interesting to note in this connection that we have found in this laboratory that it is possible to give freshmen, in a required course in chemistry, work which has relation to agriculture and seems to be of interest to them.

The work is synthetic rather than analytic or descriptive in character, and consists, in part, in preparation from the original sources of the following materials: superphosphate, ammonium sulfate (from gas liquor), high grade muriate and sulfate of potash, as well as the sulfate of potash-magnesia from crude salts, arsenate of lead, lime-sulfur, Bordeaux mixture, Paris green and various emulsions.

A student spends one or more two-hour laboratory periods on one preparation, often using the product of one day's work to make a second substance. For example, copper sulfate is made from metallic copper, and at a following exercise Bordeaux mixture and Paris green are made from the copper salt. Similarly lead nitrate is made from the oxid before the nitrate is used to prepare the arsenate of lead.

Many of these preparations, in the making, furnish excellent opportunities to illustrate the principles of mass-action and some phases of colloidal chemistry.

C. A. Peters

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THE RENOUNCING OF HONORARY DEGREES

To the Editor of Science: In your issue of October 2, I notice certain German professors have stated their intention of renouncing the honorary degrees conferred upon them by British universities. If they imagine they can do this they are, as regards Cambridge, imagining a vain thing. Our statutes, which are acts of parliament, give no power, even to the authorities of the university itself, to take away honorary degrees.

The utmost the German professors can do is to cease to use them, but they will still remain honorary doctors of Cambridge. They will go down to the tomb with this indelible stain upon their names.

A. E. Shipley

Christ's College,
Cambridge

[1] September 18, 1914, page 401.

SCIENTIFIC BOOKS

Telegraphy. By the late Sir W. H. Preece, K.C.B., F.R.S., and Sir J. Sivewright, M.A., K.C.M.G. Revised and partly rewritten by W. Llewellyn Preece. London and New York, Longmans, Green and Co., 1914. 422 pages, 269 illustrations. Price $2.25 net.

This interesting volume in the Text-Book of Science Series is a thorough revision of a smaller volume of 300 pages by the same two authors published by Longmans, Green & Co. in 1876. Although the original volume passed through nine editions, its contents remained almost unchanged. At that time, the book was practically the only one on the subject of telegraphy in Great Britain available for operators and artisans employed in the British post-office system. Great changes have naturally taken place in that system during the 38 years which have passed since the book first made its appearance. The new book has, for instance, to include telephones and telephony, neither of which is referred to in the original edition. On the other hand, it has been necessary to exclude, for want of space, some of the subjects dealt with in the original volume.

In clearness and simplicity of statement, it would be difficult for the new edition to improve upon the old. All the writings of the late Sir William Preece were signalized by their directness and lucidity. His collaborator, Sir James Sivewright, was entitled to a like share of praise for his literary presentations. Between them they wrote a volume that remained, during a generation, a standard for

the class to whom it was addressed. The traditions of the volume have been well supported by Mr. Llewellyn Preece, Sir William's son. While many of the original illustrations have been preserved and reproduced in the new edition, more than a hundred new illustrations have been incorporated.

It is so rarely that we find a man's scientific and literary production adequately brought up to date by the labor of his son, that the book before us would have a claim for recognition on this account alone.

In view of so much new material which has been introduced, it seems invidious to complain of omissions. It is to be regretted, however, that the last chapter of the original edition, devoted to "Commercial Telegraphy" and dealing with the very interesting and special administrative features of the British telegraphs, should have had to disappear, in making up the new volume. There was a characteristic quality in that presentation which we think will be missed in the new edition, and which is valuable to students of telegraphy.

The new chapters on Repeaters, Quadruplex, Multiplex, the Telephone and Wireless Telegraphy are excellent, and the treatment which they offer of those subjects accords remarkably well with the style of the original volume.

A. E. KENNELLY

A History of Japanese Mathematics. By DAVID EUGENE SMITH and YOSHIO MIKAMI. The Open Court Publishing Company, Chicago, 1914. Pp. vii + 288.

This interesting story of Japanese mathematics is presented in most attractive garb. The paper, the type and the illustrations make of it a work which it is a delight to handle, but an American must feel some regret that this beautiful book with the imprint of an American publishing house is nevertheless from the press of a German printer, W. Drugulin, Leipzig.

The Japanese mathematics is largely indigenous and, as the authors well state, it is "like her art, exquisite rather than grand." Of the six periods into which the history of their mathematics may be divided the first extends to 552 A.D., and is almost entirely a native development. The second period, from 552 to 1600, was characterized by the predominance of Chinese mathematics. The third period was a kind of renaissance which reached its highest development in Seki Kowa (1642–1708), the most famous Japanese mathematician. The fourth and fifth periods, from 1675 to 1775 and from 1775 to 1868, are marked by the development of the *wasan,* or native mathematics. Even before these periods the Jesuits had secured a foothold in China, and a Japanese student of mathematics was working under Van Schooten in Leyden as early as 1661, so that some influence of European mathematics may be confidently assumed. The sixth period is the period of the present day which, in mathematics, at least, knows nothing of political and racial boundaries.

The uncertainty of the first and second periods is best illustrated by the fact that but 17 pages are devoted to their consideration. A passage in the discussion of the Chinese "Arithmetical Rules in Nine Sections" is also significant: "If these problems were in the original text, and that text has the antiquity usually assigned to it, concerning neither of which we are at all certain, then they contain the oldest known quadratic equation."

Tangible arithmetic seems to have secured its greatest development among the Japanese. The fundamental operations with the *soroban,* a modification of the Chinese *swan-pan,* are explained in a detailed manner, and illustrated with excellent photographs. Certainly it is striking that in Chinese *swan-pan* has the meaning "reckoning table," which corresponds precisely to the Greek word from which "abacus" is derived, this also having the meaning "table," particularly for bankers. The *sangi,* or computing rods, are explained both as used for representing numbers and also as applied to the solution of algebraic equations.

Extensive numerical computation appealed greatly to the Japanese as well as to the Chinese mathematician. The game side of mathematics is represented by magic squares, and even magic circles. An approach to the meth-

ods of the calculus is found in the *yenri*, or circle principle, which tradition states was devised by Seki Kowa.

This work should appeal to a wide circle of readers, to the students of the history of science, to all interested in Japanese civilization and even to the general reader, for much of the work is non-technical. Certainly this book will contribute to a juster and broader appreciation of the Japanese genius.

LOUIS C. KARPINSKI
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The Development of Mathematics in China and Japan; Abhandlungen zur Geschichte der mathematischen Wissenschaften, Vol. XXX. By YOSHIO MIKAMI. Teubner, Leipzig, 1913. G. E. Stechert and Co., New York. Pp. x + 347.

The activity of Mr. Mikami in making the mathematics of China and Japan known to the western world is highly to be commended. Besides many articles dealing with particular problems of the history of mathematics, Mr. Mikami has an earlier work, "Mathematical Papers from the Far East," in the same series as this volume under discussion, and also another book jointly with Professor David Eugene Smith, "A History of Japanese Mathematics," published by The Open Court Publishing Company. The more active cooperation of some English-speaking historian of mathematics would have been desirable in the two volumes which were published in Germany. Professor G. B. Halsted has, indeed, prefatory notes in the volumes which imply that the task of correcting the English was entrusted to him, but the literary charm of Professor Halsted's own works is lacking here, and even unintelligible as well as non-idiomatic English mars the excellence of these works. Errors are too numerous to be listed.

The book is divided into two parts: the first 21 chapters discuss the Chinese mathematics, and the following 26 chapters the Japanese. Three chapters which are of great value to the student of the history of science are entitled, A General View of the Japanese Mathematics, A Chronology of the Japanese Mathematics, and A Short Notice of the Historical Studies of the Japanese Mathematics. Somewhat similar treatment of the Chinese portion would have added much to the value of the work. An omission in the bibliography of the historical works is Souciet (Père), *Observations mathématiques, astronomiques, etc., tirées des anciens livres Chinois, ou faites nouvellement aux Indes et a la Chine par les pères de la Comp. de Jesus* (Paris, 1729), to which my attention has been called by Professor W. W. Beman.

Considerable uncertainty attaches to the dating, and even the content, of the ancient Chinese and Japanese mathematical treatises, but this, we may say, seems somewhat characteristic of our knowledge of the early Orient, particularly India. An evidence of this uncertainty is the fact that Mikami's description of the early "Arithmetic in Nine Sections" is quite different (footnote, p. 10) from that given by T. Hayashi in his "Brief History of Japanese Mathematics" which appeared in the *Nieuw Archief*, Tweede Reeks, Deel VI. (not accessible to me).

To the student of mathematics the most striking feature of this history will doubtless be the processes of solution of equations of higher degree than the second, by means of the *sangis* or calculating pieces. These solutions require a great amount of detail and approach closely the methods of Horner and Newton. The attention paid to the "squaring of the circle" is of interest, and the approach to a determinant notation is truly striking. The student of the history of mathematics will doubtless be most impressed by the description of the early Chinese process of multiplication of an integer of several places by an integer of the same kind, for the process corresponds in many details to the methods taught in the early works on the Hindu art of reckoning.

Some allowance for the enthusiasm of a Japanese writer must be made by the reader. However, to compare the Japanese Seki with Newton, "If Seki did not surpass Newton in his achievements, yet he was no inferior of the two," is quite beyond the bounds of allowable enthusiasm, for no evidence is presented

which in the least warrants this surprising statement.

In the present state of European civilization we turn with more interest possibly than formerly to these ancient civilizations of the East. English people can only regret that when the Japanese have taken the pains to write in the English language treatises of this kind about their history that even then the publication should be effected in Germany and Holland. Surely the people of the Orient should be met by English and Americans more cordially in scholarly as well as commercial matters. Mr. Mikami has rendered a real service to the history of science by this exposition of the development of mathematics in China and Japan.

LOUIS C. KARPINSKI

UNIVERSITY OF MICHIGAN

Birds of New York. By ELON HOWARD EATON. Memoir 12, New York State Museum, John M. Clarke, Director. Part 2. Introductory Chapters; Land Birds. Albany, University of the State of New York. 1914. 4to. Pp. 719. Sixty-four colored plates, and many half-tone illustrations in the text.

In the review of Part I.[1] it was said that "Of the many manuals and reports on birds issued under authority of the various state governments none approaches in voluminous detail and fullness of illustration the present work on the 'Birds of New York,'" of which Part I., comprising the water birds and game birds, appeared in 1910. It was further stated that "the author, Elon Howard Eaton, has shown himself well fitted for the task, both the introductory matter and the systematic part giving evidence of thorough research and good judgment." This high praise is equally merited by Part II., comprising introductory chapters on bird ecology (pp. 5–46), the economic value of birds (pp. 46–51), the status of our bird laws (pp. 51–52), special measures for increasing bird life (pp. 52–58), bird refuges (pp. 58–59), private preserves (pp. 58–60), and a systematic account of the land birds (pp. 61–543).

[1] SCIENCE, N. S., Vol. XXXII., No. 866, pp. 247–48, August 19, 1910.

The chapter on bird ecology treats (1) of the fundamental factors of environment, as climatic, physiographic, character of soil, and biotic; (2) bird habits; (3) nesting sites of New York birds, in respect to whether in banks, on the ground, in tussocks, in thickets, at different elevations in trees, or in structures erected by man, including bird boxes specially provided by man; (4) bird communities, classified with reference to breeding haunts; (5) succession of bird life, with reference to climatic and edaphic conditions; (6) the influence of culture conditions, as timber cutting, draining of swamps and marshes, pruning of shade and fruit trees, and effects of agriculture; (7) birds in relation to their food habits; (8) injury done by birds, in different ways by particular species; (9) economic value of birds, as destroyers of insects, weed seeds, field mice, etc.; and, finally (10) measures for increasing bird life, as the erection of artificial nesting sites, and the planting of trees and shrubs that yield them shelter or food.

The systematic part treats of the genera and species in the sequence of the A. O. U. Checklist, from the vultures to the bluebird, in the detailed manner indicated in the review of Part I. The 65 half-tone illustrations in the text are mostly of young birds or of nests and eggs, but include a few full-length views of birds from mounted specimens; the 64 colored plates are by Fuertes, and thus scarcely need further comment, except to say that the color-printing is of very unequal merit, being for the most part good, but far from satisfactory in many of the sparrow plates and in some others, which, of course, is not the fault of the artist. The subject-matter does great credit to the author and to the state, and the work will always be the standard authority on the ornithology of New York as known at the time of its publication. As a piece of book-making it falls far short of being a model. There is no table of contents beyond the chapter titles given on the title-pages, nor any list of the text illustrations, nor of the plates; the index is placed after the plates with a hiatus in the pagination

from page 543 to page 673, presumably to cover the explanatory leaves facing the plates.

J. A. Allen

American Museum of Natural History,
New York

Nature and Development of Plants. By Carlton C. Curtis, Professor of Botany in Columbia University. Illustrated. New York, Henry Holt & Company. 1914. Pp. vii + 506.

A few years ago it fell to the reviewer's lot to discuss in these columns the first edition of this excellent text, and it is with pleasure that he offers herewith his comments on its recent revision.

It is well that a book of this kind has met with that degree of appreciation and success which has warranted its third edition in so short a time. It is rare among our text-books of botany that the essential facts of the science are presented in a style at once so clear and attractive as to hold the attention of the casual reader, to say nothing of its acceptability to students. Too often is it the tendency among writers to kill, in the average student, all interest in a subject naturally engaging, by a dictionary style of composition and a pedantic devotion to technical terminology. Technical terms are well enough in their place, but their acquisition is not the end of botanical study, and to present the nature and development of plants accurately and in simple language demands a keener appreciation of the facts and their relations, than it may require to clothe the subject in the diction of a specialist.

One of the points in which this book is especially to be commended is the effort of its author to direct attention to the economic bearings of the subject. While the deeper thinker has no difficulty in appreciating the practical value of pure science, so-called, the fact remains that most students are stimulated by a perception of the relation of this or that fact to human welfare, and the more the facts of such relation are emphasized, the less will botany have to contend for its just place in the academic program.

It is the aim of the author, as stated in the preface, that the mastery of this text shall exact strenuous effort on the part of the student, an excellent motive from the pedagogical standpoint, but an end which is better reached in the laboratory than elsewhere. Such a purpose would hardly be achieved in the present volume with its clear and simple style, unless it be in the mass and suggestiveness of its fact, which we take to be the author's intent.

The book before us is divided into two parts. The first deals with the plant as an organism, definite, vital, dynamic. In this the topics of photosynthesis, transpiration, absorption, growth, reproduction, etc., as well as the structure of the tissues concerned, are treated with special reference to the seed plant and introduces the significance of plant structures and life. Part two presents the subkingdoms of the plant world and their more common representatives, setting forth the principal features of relationship and evolution. The book should form the basis of a year's study, supplemented by lectures and laboratory work. The illustrations are excellent and well chosen.

J. E. Kirkwood

Missoula, Mont.

BOTANICAL NOTES

THE ANNIVERSARY OF A GREAT GARDEN

Several months ago the botanists of the world were asked to come to St. Louis about the middle of October to celebrate the twenty-fifth anniversary of the organization of the board of trustees of the Missouri Botanical Garden. And in planning the celebration those in charge wisely provided for a dignified program of scientific papers of notable merit, rather than for a series of congratulatory addresses. Of course there were some congratulations, but these were confined to the after-dinner speeches, at the close of the anniversary exercises. So there was a minimum of inane congratulations, and a maximum of notably meritorious botanical papers. The example of the managers of this program is commended to other managers of anniversary exercises.

Here it should be remembered that Henry

Shaw was born in England in 1800, and that coming to America he amassed a fortune by middle life, and retired from business, spending the remainder of his life in beautifying his estate in the suburbs of St. Louis. Eventually this became known as "Shaw's Garden." About 1860 it was opened to the public, and in 1889 was transferred to a board of trustees to administer the estate under the provisions of Mr. Shaw's will, as the Missouri Botanical Garden. The garden has thus no legal connection with the city of St. Louis and it even pays taxes on all of its real estate excepting only the land actually occupied by the garden itself. The garden has been fortunate in its immediate management, which is vested in its director. The first director was Professor William Trelease, who filled this position with distinguished honor until his resignation in 1912, and he was followed by Doctor George T. Moore, whose two years of service have already proved his fitness.

The general program as announced in SCIENCE for September 11, 1914, was carried out with some additions and changes due to the disturbances caused by the European war. The mornings were spent in visiting places of interest in the city, and at the garden. The midday lunches afforded excellent opportunities for extending personal acquaintances. The program of the first afternoon (October 15) included after Director Moore's address of welcome (mainly historical), eight papers, six of which were actually presented, the remaining two being read by title only. Thus the papers by Director Britton (New York), Professor Wille (Norway), Professor Bessey (Nebraska), Professor Conzatti (Mexico), Professor Coulter (Chicago), and Assistant Director Hill (Kew) were presented in full, while those by Doctor Lipsky (Russia), and Director Briquet (Geneva) were not in hand, and were presented by title only.

The program of the second afternoon (October 16) included ten papers, of which those by Professor Czapek (Prag), Director MacDougal (Desert Laboratory), Doctor Appel (Berlin), Professor Setchell (California), Director Westerdijk (Amsterdam), Professor Atkinson (Cornell), and Doctor Smith (Washington) were presented in full, while those by Director Fitting (Bonn), Director Klebs (Heidelberg), and Professor Buller (Manitoba) were presented by title only.

The closing banquet was worthy of the occasion. Those who have been fortunate enough to be bidden to the "Shaw Banquets" need no description as to what this one was like. It was notable for the profusion of floral decorations, public report asserting that more than six thousand plants were used for this purpose, including about six hundred varieties of decorative plants. In a second matter this banquet was notable in that for the first time there were women among the guests, as should be, of course, when we remember the very considerable number of women who are engaged in botanical investigation, and in botanical teaching.

TRICARPELLARY AND TETRACARPELLARY ASH FRUITS

FOR several years I have been watching some of the green ash trees (*Fraxinus pennsylvanica*) along the streets of Lincoln, having found many years ago that some of them were in the habit of producing tricarpellary fruits, in addition to their usual bicarpellary samaras. As a result, several months ago I found one tree that produced these fruits in such numbers that the case seems to me to be worthy of record. One of my assistants, Mr. F. F. Weinard, collected from this tree 87 clusters of the fruits, and found that the average number of fruits in each cluster was 25, of which on an average ten were tricarpellary. In other words of the whole number of samaras examined (2,183) there were 876 that were tricarpellary. This means that almost exactly 40 per cent. of the whole number of fruits were tricarpellary, a proportion that is quite unlooked for. In the same collection there were found four tetracarpellary fruits, that is about one fifth of one per cent.

Elsewhere in the city other trees were found that produced tricarpellary fruits, but it is a well established fact that most green ash trees produce very few, if any, of these abnormal fruits.

STAMENS AND OVULES OF CARNEGIEA GIGANTEA

THROUGH the courtesy of Director MacDougal of the Desert Botanical Laboratory at Tucson, Arizona, a lateral branch of the giant cactus (*Carnegiea gigantea*), measuring about a meter in height and twenty centimeters in diameter has been blossoming at intervals since May in the botanical plant houses of the University of Nebraska. No less than five distinct sets of flowers have appeared in this time.

From the first the number of stamens interested us, and some estimates were made of their number, but these varied so much that at last it was determined that the only thing to do was to make an accurate count of the stamens. Accordingly Mr. R. E. Jeffs, a fellow in botany, was asked to determine the number by enumerating every stamen, not making any *estimate* whatever. The result was astonishing, for it was found that there were 3,482 stamens in the flower, probably the largest number recorded for any flower.

This quite naturally raised the question of the number of ovules in the same flower, and Mr. Jeffs accommodatingly counted these also, with the result that he found 1,980 ovules. Here again the number is unexpectedly large, but the result is by no means as astonishing as in regard to the stamens. These figures are deemed worthy of publication.

CHARLES E. BESSEY

THE UNIVERSITY OF NEBRASKA

SPECIAL ARTICLES

ACTIVATION OF THE UNFERTILIZED EGG BY ULTRAVIOLET RAYS

THE sterilizing effect of the ultraviolet rays suggested the possibility that with their aid unfertilized eggs could be induced to develop, since the writer's previous experiments have shown that any substance which acts as a cytolytic agency can also produce artificial parthenogenesis. It was found, indeed, that the unfertilized eggs of the sea urchin *Arbacia*, as well as those of the annelid *Chætopterus*, can be caused to develop by a short treatment with the Heraeus quartz mercury arc lamp. The lamp was fed with a current of 3.4 amperes, the voltage of which was 220. The alleged candle power of this light was 3,000. The eggs were at the bottom of a glass dish covered by a layer of 2 cm. of sea water. The dish was open on top and it stood directly under the lamp at a distance of 15 cm. In order to prevent the temperature of the eggs from rising above the normal room temperature the glass vessel containing the eggs was surrounded by melting ice. The eggs formed a single layer on the bottom of the dish, since it seemed that the eggs lying on top screened the eggs under them from the effect of the ultraviolet light.

When unfertilized eggs of *Arbacia* were exposed to the ultraviolet light for ten minutes, many and sometimes all formed fertilization membranes. In some of the eggs this membrane was only the fine gelatinous film which the writer called an atypical membrane; others possessed a typical normal fertilization membrane. When nothing further was done with the eggs they underwent, at room temperature, cytolysis without segmentation. When the temperature was below room temperature (about 12° C.) some of the eggs segmented into two or four cells, but then perished. When the eggs were put for twenty minutes into hypertonic sea water, about ten minutes after the treatment with ultraviolet light, they developed into larvæ. The eggs had suffered, however, since few developed beyond the gastrula stage. When the eggs were exposed too long to the ultraviolet light (*e. g.*, twenty minutes) they formed fertilization membranes, but were injured to such an extent that they could no longer segment or develop.

It was of interest that a cover glass of 0.1 mm. thickness prevented all effects of ultraviolet light even if the eggs were exposed forty or sixty minutes. Such eggs remained normal. A layer of from 2 to 6 cm. of sea water did not prevent the effect of the ultraviolet rays. Neither did the rather thick walls of a quartz test tube.

The membrane formation by ultraviolet rays took place in the absence as well as in the presence of oxygen. When unfertilized eggs were put into quartz test tubes from which all the oxygen had been driven out by sending a powerful current of hydrogen through for four

hours, the ultraviolet light still caused membrane formation. This effect of the ultraviolet rays was not prevented by even an excessive quantity of NaCN, which inhibits oxidation in the egg. The membrane formation under the influence of ultraviolet light took place in neutral solutions as well as in weakly alkaline ones.

The calling forth of the membrane formation was due to a direct action of the ultraviolet rays upon the egg and not to a product formed by the rays in the sea water or in the air. For sea water which had been exposed to the influence of the rays, no matter how long, without containing eggs, did not cause membrane formation when the eggs were put into it after the ultraviolet light was turned off.

These experiments show that causation of membrane formation in the unfertilized sea urchin egg and the subsequent inducement to development were due to the direct effect upon the egg of ultraviolet waves below 2607 Å. u., since, according to Dr. and Madame V. Henri, waves below this range can not penetrate a cover glass of 0.14 mm. thickness. It is not possible to state in which way the ultraviolet waves caused the membrane formation in the egg except that it could take place without free oxygen as well as in the presence of NaCN.

The results mentioned thus far were obtained in the egg of the sea urchin. The egg of *Chætopterus,* after an exposure of from five to ten minutes to the ultraviolet rays under the conditions mentioned above, developed into swimming larvæ, without cell division.

Since Röntgen rays are only very short light waves, and since they also cause cytolysis, they should also cause membrane formation of the unfertilized egg. It is of interest that G. Bohn states that Röntgen rays induce artificial parthenogenesis. His experiments were made before the rôle of the membrane formation (or the alteration of the surface of the egg) was recognized as a necessary step in development, and he therefore does not mention whether or not Röntgen rays induce membrane formation.

JACQUES LOEB
THE ROCKEFELLER INSTITUTE FOR MEDICAL RESEARCH, NEW YORK

ON THE FEASIBILITY OF DETERMINING EXPERIMENTALLY THE LUNAR AND SOLAR DEFLECTION OF THE VERTICAL BY MEANS OF TWO CONNECTED WATER TANKS

FOR some time I have had in mind the essentials of the arrangement or apparatus described below, the purpose of which is to ascertain the deflection of the vertical as disturbed from its mean position by the attraction of the moon and sun. It may not be new; but I have never seen it described or referred to elsewhere.

Briefly described, such apparatus would consist of two tanks or cisterns of equal diameters and of equal depths, located some distance apart, upon the same level, and connected by means of a pipe. This pipe should be of metal excepting for some distance near its central portion where a glass section or length of much smaller diameter should be inserted. The pipe should be attached to the bottoms of the tanks in order to avoid complications which would otherwise arise should the temperatures of the water in the two tanks become somewhat unequal. But if the pipes are attached to the bottoms of the tanks, the unequal expansion of the water will not seriously affect the equilibrium and so will not set up any flow of consequence from one tank to the other.

At any given place upon the earth's surface the direction of the instantaneous vertical continually deviates from its mean position by a small angle dependent upon the time (or local hour angle) selected and the positions of the moon and sun relative to the earth's center.

Ignoring the attraction of the disturbed oceans, the plumbline upon an unyielding earth deviates in accordance with the impressed horizontal forces. These forces, in terms of g or terrestrial gravity are:

Eastward force,

$$= -0.0000001684 \cos\lambda[\mathrm{M}_2 \sin(\mathrm{m}_2 t + \arg_0 \mathrm{M}_2) + \mathrm{S}_2 \sin(\mathrm{s}_2 t + \arg_0 \mathrm{S}_2) + \cdots].$$

$$- 0.0000001684 \sin\lambda[\mathrm{K}_1 \sin(\mathrm{k}_1 t + \arg_0 \mathrm{K}_1) + \mathrm{O}_1 \sin(\mathrm{o}_1 t + \arg_0 \mathrm{O}_1)$$
$$\mathrm{P}_1 \sin(\mathrm{p}_1 t + \arg_0 \mathrm{P}_1) + \cdots].$$

Southward force,

$$= 0.0000001684 \cos\lambda \sin\lambda[\mathrm{M}_2 \cos(\mathrm{m}_2 t + \arg_0 \mathrm{M}_2) + \mathrm{S}_2 \cos(\mathrm{s}_2 t + \arg_0 \mathrm{S}_2) + \cdots].$$

$$- 0.0000001684 \cos 2\lambda [K_1 \cos (k_1 t + \arg_0 K_1) + O_1 \cos (o_1 t + \arg_0 O_1) + P_1 \cos (p_1 t + \arg_0 P_1) + \cdots].$$

Here M_2, S_2, K_1, O_1, P_1, denote abstract numbers or coefficients of tidal constituents bearing these names and are equal to 0.4543, 0.2114, 0.2652, 0.1886 and 0.0878, respectively. The angles in the parentheses are the arguments of the forces which give rise to the various constituent tides. λ denotes the latitude of the place or station selected.

The above expressions also denote the instantaneous deviation of the vertical expressed in radians (1 radian $= 206265''$).

Let L denote the horizontal distance between the centers of the two tanks. Let d denote the inside diameter of the small transparent pipe used and l its length. Let Ω denote the area of the water surface in either tank.

For convenience, consider here only the principal periodic term of the lunar semidiurnal tide and let the two tanks be situated upon the earth's equator. The foregoing expressions will enable one to make similar computations for all terms given, for any latitude, and for any orientation of the apparatus.

At a time three lunar hours before the upper or lower culmination of the mean moon, the surface of the water in the eastern tank will be $L \times 0.0000001684 \times 0.4543 = 0.0000000765\, L$ units higher than the surface of the water in the western tank. The reverse will be the case three lunar hours after either meridian passage.

The amount of water passing through any cross section of the connecting pipe will be

$$\Omega L \times 0.0000000765$$

cubic units.

If $2b$ denote the entire distance over which the water in the glass section of the pipe moves, we must have

$$2b \frac{d^2}{4} \pi = \Omega L \times 0.0000000765;$$

$$\therefore 2b = L \times 0.0000000765 \times \frac{\text{area tank}}{\text{cross section small pipe}}.$$

If this ratio be 10,000, then

$$2b = 0.000765\ L$$

units, and if the length of L be 10,000 units (say centimeters) then

$$2b = 7.65 \text{ units (centimeters)}.$$

Now the time required in making this transfer of water is 6 lunar hours, or 22,357 seconds; $\therefore$ the average velocity in the small tube will be $2b \div 22{,}357 = 0.00034$ units per second, and, because the disturbing force here used is harmonic, the maximum velocity will be $2b \div 14{,}233 = 0.00054$ units per second, and the maximum flux, $0.00054 \frac{\pi}{4} d^2$ cubic units per second.

This small velocity in a pipe say 1 cm. in diameter implies stream-line motion; and so we can compute by Poiseuille's laws the flux, or rate of discharge, under given or assumed conditions as regards the diameter and length of pipe and the difference of pressure at the two ends of this pipe. The formula for this is

$$\text{Flux} = \frac{\pi}{8\mu} \left(\frac{d}{2}\right)^4 \frac{p_1 - p_2}{l}$$

cubic centimeters per second. In the first place, assume that

$$p_1 - p_2 = L \times 0.0000000765\ g\rho.$$

Here ρ denotes the density of the water and is about unity;

$$\mu = \frac{0.0178}{1 + 0.337\theta + 0.000221\theta^2}$$

θ denoting the temperature Centigrade; and $g = 981$ centimeters per second.

If $l = 100$ cm., and $L = 10{,}000$, the flux, ignoring the resistance in the larger pipe, would amount to

$$\frac{\pi}{8\mu} \frac{1}{16} \frac{0.000765}{100} g$$

cubic centimeters per second, a quantity many times greater than the maximum flux necessitated by the water transference.

For a pipe 100 meters long and of diameter $\sqrt{10}$ centimeters, the flux will be the same as for the small pipe one meter long just considered.

From the above it can be seen that the effect of all pipe resistance can be so reduced by varying the diameters and lengths as to

not seriously interfere with the quantity of water actually transferred; and a little consideration will show that the amount of such interference can be calculated with some certainty.

Nothing has been said as to the nature of a float suitable for indicating the motion in the glass pipe. Somewhat as Forel in his "plemyrameter" used corks weighted to the specific gravity of water, so here a cylinder having a diameter somewhat less than the inside diameter of the glass pipe, and having the specific gravity of water, could be used. Each of the metal ends of such cylinder should be pierced by a hole, so that the cylinder could be threaded loosely on a fine wire stretched along the axis of the small pipe. However, some other style of float may be preferable to this. The readings should be made at regular hourly or half-hour intervals.

The amount whereby the observed *b*, properly corrected for pipe resistance, may fall short of its simple theoretical value, *i. e.*, its value on a perfectly rigid earth devoid of oceans, is an important factor in the determination of the amount of yielding of the earth to the known tidal forces, and so in the determination of the earth's rigidity. The interpretation of such measurements, however, constitutes no part of the present communication.

R. A. Harris

Washington, D. C.,
March 28, 1914

[Since the above was written, I have seen the surprisingly consistent results obtained by Professor Michelson and published in the *Journal of Geology* and in the *Astrophysical Journal* for March, 1914; also the account published in Science for June 26, 1914. It will be recalled that in these determinations, the vertical oscillation of the water's surface at the two ends of a half-filled horizontal pipe was the quantity measured. R. A. H., September 29.]

APPROXIMATE MEASUREMENT OF TEXTILE FIBERS

This note is hardly the place for the demonstration of the following theorem. However, it is readily capable of demonstration, and the reader of a mathematical turn of mind will at once perceive the line of proof.

Theorem. If an infinite series consisting of straight parallel linear elements of every possible length, each element arranged perpendicularly to and symmetrically to a given straight line, be bisected along that line and the two half-series thus produced be placed with the former outer edges of adjacent, then if the elements of one of the half-series be systematically rearranged, its longest element matched to the shortest of the other half-series and its next longest to the next shortest of the other half-series and so on, a new parallel-sided uniform series will be produced, each of whose elements has a length equal to the mean length of the elements of the original series.

If the theorem be changed so that the elements are stated to vary in length within prescribed limits, then for this modified theorem the line of demonstration as well as the final result is the same.

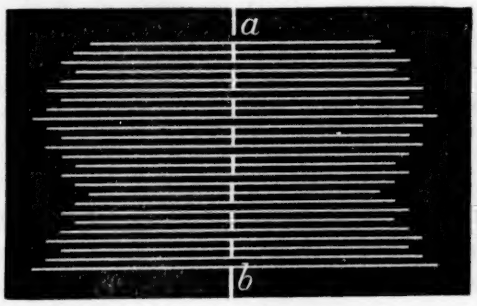

Fig. 1. Straight elements varying in length within prescribed limits, arranged symmetrically with reference to a given straight line, *a–b*, in accordance with theorem.

If the number of elements is limited, say, for example, to a few thousand, the result becomes approximate; and if the elements instead of having their middle points on the given straight line are arranged so that their middle points fall at random on either side of the given straight line a distance less than half the length of the shortest element, then the reconstructed series will have a width approximately equal to the mean length of the original elements; for it will always be pos-

sible to pair the elements whose middle points fall to the right with those whose middle points fall to the left in such a way, the long with the short, as to secure the result stated in

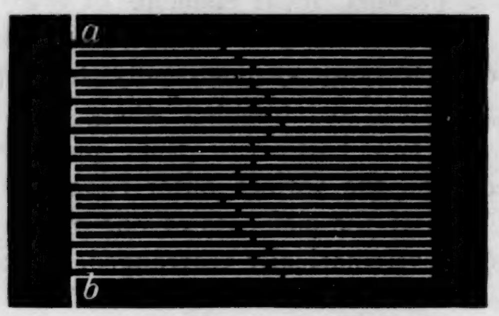

Fig. 2. Series shown in Fig. 1 bisected, and its left half transposed and turned over. For the sake of simplicity, in Fig. 1 the elements are so assorted that in Fig. 2 they match without rearrangement. The width of the second series (Fig. 2) equals the mean length of the original elements.

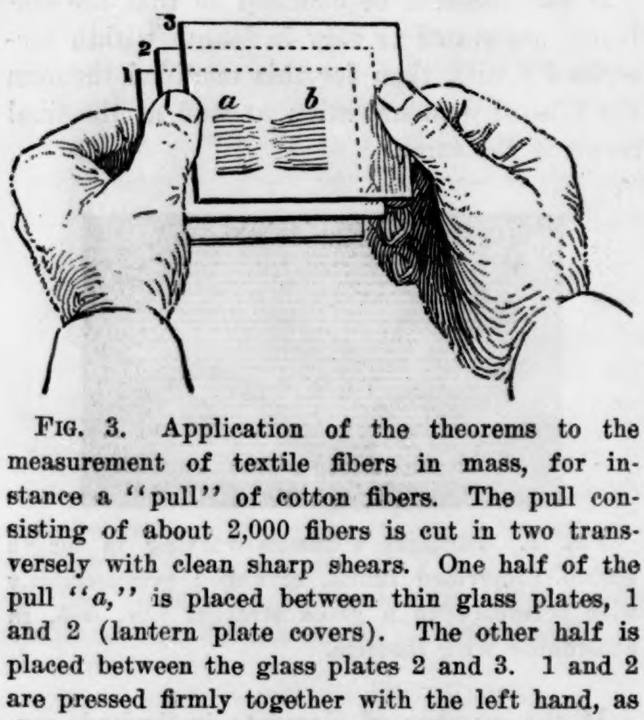

Fig. 3. Application of the theorems to the measurement of textile fibers in mass, for instance a "pull" of cotton fibers. The pull consisting of about 2,000 fibers is cut in two transversely with clean sharp shears. One half of the pull "a," is placed between thin glass plates, 1 and 2 (lantern plate covers). The other half is placed between the glass plates 2 and 3. 1 and 2 are pressed firmly together with the left hand, as shown, while 3 is held loosely with only its left hand edge in contact with 2 and resting against the left thumb, its right hand edge being lifted so as to enable the operator to move the fibers "b" back and forth over the fibers "a" by friction. Or the fibers "b" may be moved back and forth in any one of several different ways. For instance, the left edge of "3" may be used to move "b" back and forth on "2." When "a" and "b" are adjusted the three plates of glass are held in the left hand and the measuring scale applied with the right hand.

the theorem approximately, the degree of approximation depending on the number of the original elements and the uniformity of their increments in length when arranged in the order of their magnitude.

It has been ascertained by comparison with the results of my accurate method of measuring the length of fine crooked fibers, a description of which has already been published, that if a series of textile fibers be arranged in a manner similar to that described in the theorems, the mean length of the fibers can be measured approximately, if proper allowance be made for the "fly-back," or shortening of the fibers, due to their elasticity.

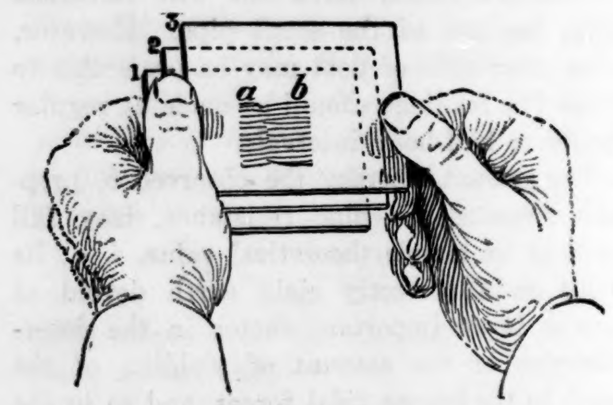

Fig. 4. The halves of the "pull" shown in Fig. 3 matched ready for measurement. The halves are adjusted against a strong transmitted light and yet with a good top-light; for instance, against sky-light reflected from a mirror laid on a table near a window; "b" is so adjusted over "a" that the fiber masses present the same shade from end to end. This simple optical method is found to approximate the conditions of the theorems. Care should be taken not to disturb the parallelism of the fibers. The width of the series, as arranged in Fig. 4, represents the mean length of the fibers minus the "fly-back." This latter, about one millimeter in twenty-five for well-conditioned cotton fibers, has to be added. The results are accurate to the fraction of a millimeter. The method is definite, readily learned, and easily applied.

It is intended to publish details in connection with this approximate method of measuring textile fibers in a separate publication.

N. A. Cobb

Bureau of Plant Industry,
Department of Agriculture,
September 25, 1914